[Title]			[Instructor]		
Advanced Course of Materials Design for Fuel Cells I			Hiroyuki Uchida / Kenji Miyatake		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391410 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／II	English／Japanese

[Outline and purpose]

Fuel cells are electric power supply devices, which convert chemical energy to electric energy directly and reciprocally. Among them, polymer electrolyte fuel cells (PEFCs) for electric vehicles, portable devices, and residential power supply and solid oxide fuel cells (SOFCs) as on-site power generation have attracted a considerable attention. In this class, principle, design and evaluation of these fuel cells and their component materials will be discussed.

[Objectives]

To understand principle and evaluation of PEFCs and SOFCs and their component materials

[Requirements]

Basic knowledge on electrochemistry and physical chemistry

[Evaluation]

Report and examination: 50%
Mark given for class participation: 50%

[Textbooks]

Denkikagakugairon (co-authored by Matsuda and Iwakura), Maruzen, ISBN: 4621039962

[References]

None

[Schedule]

1. Electrochemistry of fuel cells 1
2. Electrochemistry of fuel cells 2
3. Principle and research trend of fuel cells 1
4. Principle and research trend of fuel cells 2
5. Design of fuel cell electrocatalysts: cathode catalysts 1
6. Design of fuel cell electrocatalysts: cathode catalysts 2
7. Design of fuel cell electrocatalysts: anode catalysts 1
8. Design of fuel cell electrocatalysts: anode catalysts 2
9. Methanol oxidation catalysts 1
10. Methanol oxidation catalysts 2
11. Design of highly dispersed catalysts 1
12. Design of highly dispersed catalysts 2
13. Design of functional materials 1
14. Design of functional materials 2
15. Summary

[Title]			[Instructor]		
Advanced Course of Materials Design for Fuel Cells II			Kenji Miyatake / Hiroyuki Uchida		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391420 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／II	English／Japanese

[Outline and purpose]

Fuel cells are electric power supply devices, which convert chemical energy to electric energy directly and reciprocally. Among them, polymer electrolyte fuel cells (PEFCs) for electric vehicles, portable devices, and residential power supply and solid oxide fuel cells (SOFCs) as on-site power generation have attracted a considerable attention. In this class, principle, design and evaluation of these fuel cells and their component materials will be discussed.

[Objectives]

To understand principle and evaluation of PEFCs and SOFCs and their component materials

[Requirements]

Basic knowledge on electrochemistry and physical chemistry

[Evaluation]

Report and examination: 50%
Mark given for class participation: 50%

[Textbooks]

Denkikagakugairon (co-authored by Matsuda and Iwakura), Maruzen, ISBN: 4621039962

[References]

None

[Schedule]

1. Fuel cells and polymers 1
2. Fuel cells and polymers 2
3. Proton conductive polymers for fuel cells (design and synthesis) 1
4. Proton conductive polymers for fuel cells (design and synthesis) 2
5. Proton conductive polymers for fuel cells (structure and properties) 1
6. Proton conductive polymers for fuel cells (structure and properties) 2
7. Proton conductive polymers for fuel cells (evaluation and application) 1
8. Proton conductive polymers for fuel cells (evaluation and application) 2
9. Component materials of SOFCs: solid electrolytes 1
10. Component materials of SOFCs: solid electrolytes 2
11. Component materials of SOFCs: electrodes 1
12. Component materials of SOFCs: electrodes 2
13. Intermediate-temperature SOFCs 1
14. Intermediate-temperature SOFCs 2
15. Summary

[Title]			[Instructor]		
Advanced Course of Catalyst Design for Electrodes I			Shinji Nohara / Makoto Uchida / Katsuyoshi Kakinuma		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391430 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Wed.／I	Japanese

[Outline and purpose]

Fuel cells have attracted much attention as key technologies of energy conversion to solve the energy and global environment issues. Especially, polymer electrolyte fuel cells (PEFCs) have been intensively developed for the extensive spread as residential cogeneration systems and automotive power sources. In this course, design guideline, preparation and evaluation methods and development trend of electrocatalysts and catalyst layers with important roles in the PEFCs will be studied. Furthermore, lectures on fuel cell systems will be given, accompanied with practical science based on progressive experience in companies.

[Objectives]

To learn expert knowledge and advanced technology on electrocatalysts and catalyst layers in PEFCs, and fuel cell systems

[Requirements]

Basic knowledge on electrochemistry, physical chemistry, materials chemistry, and thermodynamics

[Evaluation]

Report and examination: 60%
Attendance: 40%

[Textbooks]

None

[References]

1.（監修）田村英雄、（編著）内田裕之、池田宏之助、岩倉千秋、高須芳雄, 固体高分子形燃料電池のすべて, エヌティーエス (in Japanese)
2. 松田好晴、岩倉千秋共著, 電気化学概論, 丸善 (in Japanese)

[Schedule]

1. Overview and significance of energy and global environmental issues
2. Electrochemistry of fuel cells (1)
3. Electrochemistry of fuel cells (2)
4. Principles and development status of various fuel cells (1)
5. Principles and development status of various fuel cells (2)
6. Design for electrocatalysts in PEFCs (1)
7. Design for electrocatalysts in PEFCs (2)
8. Design for practical electrocatalysts in PEFCs (1)
9. Design for practical electrocatalysts in PEFCs (2)
10. Design for pore structure and catalyst effectiveness of the catalyst layer in PEFCs (1)
11. Design for pore structure and catalyst effectiveness of the catalyst layer in PEFCs (2)
12. Design guideline and evaluation methods of the catalyst layer in PEFCs (1)
13. Design guideline and evaluation methods of the catalyst layer in PEFCs (2)
14. Current status and future prospects of PEFC systems
15. Summary

[Title]			[Instructor]		
Advanced Course of Catalyst Design for Electrodes II			Makoto Uchida / Katsuyoshi Kakinuma / Shinji Nohara		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391440 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Wed.／I	Japanese

[Outline and purpose]

Fuel cells have attracted much attention as key technologies of energy conversion to solve the energy and global environment issues. Especially, polymer electrolyte fuel cells (PEFCs) have been intensively developed for the extensive spread as residential cogeneration systems and automotive power sources. In this course, design guideline, preparation and evaluation methods and development trend of electrocatalysts and catalyst layers with important roles in the PEFCs will be studied. Furthermore, lectures on fuel cell systems will be given, accompanied with practical science based on progressive experience in companies.

[Objectives]

To learn expert knowledge and advanced technology on electrocatalysts and catalyst layers in PEFCs, and fuel cell systems

[Requirements]

Basic knowledge on electrochemistry, physical chemistry, materials chemistry, and thermodynamics

[Evaluation]

Report and examination: 60%
Attendance: 40%

[Textbooks]

None

[References]

（監修）田村英雄、（編著）内田裕之、池田宏之助、岩倉千秋、高須芳雄, 固体高分子形燃料電池のすべて, エヌティーエス (in Japanese)

[Schedule]

1. Overview and significance of energy and global environmental issues
2. Electrochemistry of fuel cells
3. Principles and development status of various fuel cells
4. Design for electrocatalysts in PEFCs
5. Design for pore structure and catalyst effectiveness of the catalyst layer in PEFCs
6. Environmental policy and industry-academia collaboration for fuel cells
7. Characteristics and development history of various PEFC systems (1)
8. Characteristics and development history of various PEFC systems (2)
9. Challenges from the viewpoint of manufacturers in R & D of fuel cells for residential use (1)
10. Challenges from the viewpoint of manufacturers in R & D of fuel cells for residential use (2)
11. Present status and future prospects of social environments such an international standardization in fuel cells for residential use (1)
12. Present status and future prospects of social environments such an international standardization in fuel cells for residential use (2)
13. Present status and future prospects of next-generation vehicles (1)
14. Present status and future prospects of next-generation vehicles (2)
15. Summary

[Title]			[Instructor]		
Advanced Course of Engineering for Solar Energy Conversion I			Hiroshi Irie		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391450 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	1st Semester	Wed.／II	English／Japanese

[Outline and purpose]

A light-related system is one of the candidate technologies for sustainable energy conversion and environmental preservation. We will learn such light-related systems based on mainly physical chemistry as well as quantum chemistry and solid state physics.

[Objectives]

1. To understand the interaction of light with solids, and successive phenomena

[Requirements]

Physical Chemistry, Quantum chemistry, Solid state physics

[Evaluation]

Report: 50%
Attendance: 50%

[Textbooks]

[References]

魚崎浩平、米田龍、高橋誠、金子晋（共訳）：固体の電子構造と化学、技報堂出版、1989 年（in Japanese）

[Schedule]

1. Introduction
2. Light, wave-particle durability 1
3. Light, wave-particle durability 2
4. Band theory 1
5. Band theory 2
6. Interaction of light with solids
7. Solar energy conversion 1: To chemical energy 1
8. Solar energy conversion 1: To chemical energy 2
9. Solar energy conversion 2: To hydrogen energy 1
10. Solar energy conversion 2: To hydrogen energy 2
11. Solar energy conversion 3: To electricity 1
12. Solar energy conversion 3: To electricity 2
13. Energy conversion: Heat to electricity 1
14. Energy conversion: Heat to electricity 2
15. Summary

[Title]			[Instructor]		
Advanced Course of Engineering for Solar Energy Conversion II			Hiroshi Yanagi		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391460 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	1st Semester	Wed.／II	English／Japanese

[Outline and purpose]

Students learn the fundamental principle of standard and new concept solar cells

[Objectives]

To understand the fundamental principle of standard and new concept solar cells

[Requirements]

A good grounding in Physical Chemistry, Inorganic Chemistry, Quantum Chemistry and Semiconductor Physics

[Evaluation]

1 final examination　20%
2 midterm examination　20%
3 homework　20%
4 class participation　40%

[Textbooks]

[References]

山口　真史・M･A･グリーン・大下　祥雄・小島　信晃, 太陽電池の基礎と応用, 丸善 (in Japanese)
Martin A. Green, Solar Cells, University of New South Wales
Peter Wurfel, 太陽電池の物理, 丸善 (in Japanese)
Peter Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts, Wiley-VCH

[Schedule]

１．Introduction
２．Solar cells and sunlight
３．Semiconductor properties
４．Review of device physics
５．pn junction diodes
６．Efficiency
７．Standard Si solar cells
８．Amorphous Si solar cells
９．Midterm examination
１０．Compound-semiconductor Solar cells
１１．Tandem cells
１２．Organic solar cells
１３．Quantum dot solar cells
１４．Future view
１５．Final examination

[Title]			[Instructor]		
Advanced Course of Quantum Science for Semiconductors II			Youichi Nabetani		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391480 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／I	English／Japanese

[Outline and purpose]

Quantum effects caused by refinement of semiconductor have a great influence on electronic and optical properties. We can create devices that cannot be realized by bulk semiconductors by using quantum effects. Here we discuss about quantum structures of semiconductors.

[Objectives]

(1) Understanding of refinement technics of semiconductor crystals.
(2) Understanding of structural characterization of semiconductor quantum structures.
(3) Understanding of electronic and optical characterizations of semiconductor quantum structures.

[Requirements]

semiconductor physics, electronic properties, quantum mechanics

[Evaluation]

Through the commentaries such as the latest specialty treatises about the associated item, presentation, consideration, discussion, we evaluate a basic scholastic ability, technical knowledge, application power generally.

[Textbooks]

None

[References]

None

[Schedule]

Three to four lectures are done for each followings
1-5. Understanding of refinement technics of semiconductor crystals.
6-10. Understanding of structural characterization of semiconductor quantum structures.
11-15. Understanding of electronic and optical characterizations of semiconductor quantum structures.

[Title]			[Instructor]		
Advanced Course of Science for Solid State Materials I			Satoshi Wada		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391490 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Mon.／I	English／Japanese

[Outline and purpose]

The behavior and mechanisms of electrical, magnetic and optical properties which are significant properties of solid materials will be lectured over from the basics. The aim of this lecture is acquisition of relationship between crystal structure and the electrical, magnetic and optical properties.

[Objectives]

1. To understand behavior and mechanism of electrical, magnetic and optical properties
2. To acquire consideration competency for correlation of electrical, magnetic and optical properties with the crystal structure, sorts of bond and composed elements of the solid

[Requirements]

Crystal structure of solid state materials

[Evaluation]

examinations: 30%
reporting assignment / mini-exam : 30%
attendance / attitude : 30%
presentation : 10%

[Textbooks]

Anthony R. West, Basic Solid State Chemistry, Second Edition, JOHN WILEY & SONS, LTD,
ISBN:0-471-98756-5

[References]

[Schedule]

1. Metallic conductivity
2. Superconductivity I
3. Superconductivity II
4. Semiconductivity
5. Ionic conductivity : metal halides
6. Ionic conductivity : solid electrolytes I
7. Ionic conductivity : solid electrolytes II
8. Ionic conductivity : solid electrolytes III
9. Dielectric materials, Ferroelectricity, Pyroelectricity and Piezoelectricity
10. Magnetic properties : behavior substances in a magnetic field
11. Magnetic properties : superexchange interaction
12. Magnetic properties : examples of materials I
13. Magnetic properties : examples of materials II
14. Optical properties
15. Final examination

[Title]			[Instructor]		
Advanced Course of Science for Solid State Materials II			Takahiro Takei		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391500 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Mon.／I	English／Japanese

[Outline and purpose]

The behavior and mechanisms of electrical, magnetic and optical properties which are significant properties of solid materials will be lectured over from the basics. The aim of this lecture is acquisition of relationship between crystal structure and the electrical, magnetic and optical properties.

[Objectives]

1. To understand behavior and mechanism of electrical, magnetic and optical properties
2. To acquire consideration competency for correlation of electrical, magnetic and optical properties with the crystal structure, sorts of bond and composed elements of the solid

[Requirements]

Crystal structure of solid state materials

[Evaluation]

examinations: 30%
reporting assignment / mini-exam : 30%
attendance / attitude : 30%
presentation : 10%

[Textbooks]

Anthony R. West, Basic Solid State Chemistry, Second Edition, JOHN WILEY & SONS, LTD,
ISBN:0-471-98756-5

[References]

[Schedule]

1. Metallic conductivity
2. Superconductivity I
3. Superconductivity II
4. Semiconductivity
5. Ionic conductivity : metal halides
6. Ionic conductivity : solid electrolytes I
7. Ionic conductivity : solid electrolytes II
8. Ionic conductivity : solid electrolytes III
9. Dielectric materials, Ferroelectricity, Pyroelectricity and Piezoelectricity
10. Magnetic properties : behavior substances in a magnetic field
11. Magnetic properties : superexchange interaction
12. Magnetic properties : examples of materials I
13. Magnetic properties : examples of materials II
14. Optical properties
15. Final examination

[Title]			[Instructor]		
Advanced Course of Design for Advanced Inorganic Materials I			Isao Tanaka / Nobuhiro Kumada		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391510 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／I	Japanese／English

[Outline and purpose]

Crystal structure, crystal defects, functions and property of functional inorganic compounds are acquired as combined with scientific research fields of inorganic industrial chemistry, crystal engineering, materials engineering. Also recent topics about properties, characterization and crystal structures of functional inorganic compounds are discussed.

[Objectives]

1. to understand point group and instoichiometry of oxides
2. to understand drawing technique of crystal structure

[Requirements]

inorganic chemistry, solid state chemistry, materials engineering, physical chemistry, electronic physical properties

[Evaluation]

Homework/ examination：70%
audit attitude：10%
presentation：20%

[Textbooks]

Anthony R. West, Basic Solid State Chemistry , Second Edition, John Wiley & Sons Ltd., ISBN:0471987557

[References]

[Schedule]

1. Symmetry and crystal systems
2. Understanding point groups on the basis of symmetry
3. Microscopy of crystalline materials
4. Function and property by crystal defects
5. Instoichiomerty of oxides
6. Lattice defects in oxides
7. defect concentration and defect equilibrium
8. Basis of crystalline materials
9. Electrical and mechanical properties of crystalline materials
10. Chemical properties of crystalline materials
11. Characterization of physical properties
12. Relation between crystal structure and physical properties
13. Analysis technique of crystal structure
14. Recent topics
15. Summary

[Title]			[Instructor]		
Advanced Course of Design for Advanced Inorganic Materials II			Nobuhiro Kumada / Isao Tanaka		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391520 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／I	Japanese／English

[Outline and purpose]

Synthesis and crystal growth techniques for solid state materials are acquired on the base of phase equilibrium in this course. Also crystal chemistry, X-ray crystal structure analysis, characterization for solid state materials are acquired.

[Objectives]

1. to understand phase equilibrium and the application of the phase equilibrium for synthesis techniques of solid state materials
2. to understand techniques of crystal structure analysis

[Requirements]

inorganic chemistry, solid state chemistry, materials engineering, physical chemistry, electronic physical properties

[Evaluation]

homework/ examination : 70%
audit attitude : 10%
presentation : 20%

[Textbooks]

Anthony R. West, Basic Solid State Chemistry , Second Edition, John Wiley & Sons Ltd., ISBN:0471987557

[References]

[Schedule]

1. Rule about phase equilibrium
2. Understanding and application of monocomponent systems
3. Solid solutions
4. Understanding and application of two component systems
5. Thermal analysis for preparation of phase diagrams
6. Synthesis techniques for materials
7. Fundamentals and applications of crystal growth
8. Inorganic chemistry and basis of solid state chemistry
9. Fundamentals of synthesis for solid state materials
10. Sol-gel synthesis of inorganic materials
11. Synthesis by hydrothermal reactions
12. Soft chemical reaction
13. Thin film preparation by gas phase reaction
14. Synthesis by electrochemical reactions
15. Summary

[Title]			[Instructor]		
Advanced Course of Science for Surfaces and Interfaces I			Junji Inukai / Toshihiro Miyao / Mitsuru Wakisaka		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391530 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	1st Semester	Fri.／I	Japanese / English

[Outline and purpose]

Learning interfacial chemistry, surface crystallography, and surface analytical methods for understanding surface science papers and for applying the knowledge to the present researches.

[Objectives]

1. Acquiring fundamental knowledge on interfacial chemistry.
2. Understanding atomic-level surface geometric structures.
3. Acquiring knowledge on surface analytical methods.
4. Understanding the basic of surface reactivity.

[Requirements]

Basic knowledge on inorganic chemistry, quantum chemistry, and crystallography.

[Evaluation]

Class participation 70%
Reports, quiz, and examination 30%

[Textbooks]

1. Atkins' Physical Chemistry, Peter Atkins.
2. Physical chemistry, Gordon M. Barrow

[References]

Given suitably.

[Schedule]

1. Introduction to surfaces and interfaces
2. Colloidal dispersion
3. Interfacial chemistry and nanoscience
4. Surface crystallography I (surface structure of single crystalline)
5. Surface crystallography II (surface reconstruction, adlayer)
6. Surface crystallography III (surface notations)
7. Surface crystallography IV (reciprocal space)
8. Surface analytical methods V (surface geometric structure)
9. Surface analytical methods VI (surface electrical structure)
10. Introduction to surface infrared spectroscopy
11. Application of surface infrared spectroscopy to electrode surfaces
12. Adsorption at surface (introduction of adsorption)
13. Adsorption at surface (methodology of adsorption)
14. Adsorption at surface (physisorption)
15. Adsorption at surface (chemisorption)

[Title]			[Instructor]		
Advanced Course of Science for Surfaces and Interfaces II			Toshihiro Miyao / Junji Inukai / Mitsuru Wakisaka		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391540 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	1st Semester	Fri.／I	Japanese / English

[Outline and purpose]

Comprehending basic theory of surface science, surface analytical methods, and surface reactions for the application to the present researches.

[Objectives]

Understanding the basic ideas of following topics.
1) Reciprocal space.
2) Chemical bonds in solid and at surface.
3) Band theory.
4) Surface analytical methods.
5) Surface reaction.

[Requirements]

Advanced Course of Science for Surfaces and Interfaces II must have been completed.

[Evaluation]

Class participation 70%
Reports, quiz, and examination 30%

[Textbooks]

1. Atkins' Physical Chemistry, Peter Atkins.
2. Physical chemistry, Gordon M. Barrow

[References]

Given suitably.

[Schedule]

1. Introduction to surface science
2. Surface symmetry and surface diffraction
3. Surface bonding I: Ionic and covalent bonding
4. Surface bonding II: Metallic molecular, and hydrogen bonding
5. Surface electronic structure
6. Introduction to band theory
7. Surface analyses for surface electronic structure
8. Surface infrared spectroscopy I: Principle of IRAS
9. Surface infrared spectroscopy II: Adsorption/oxidation of CO on Pt electrodes
10. Surface infrared spectroscopy III: Adsorption of hydrogen and hydrogen evolution on Pt electrode
11. Surface infrared spectroscopy IV: Adsorption of O_2 and ORR on Pt electrode
12. Adsorption at surface (interpretation of adsorption isotherms)
13. Adsorption at surface (surface characterization using adsorption phenomena)
14. Adsorption at surface (surface catalysis)
15. Adsorption at surface (catalytic reaction mechanisms at solid surfaces)

[Title]			[Instructor]		
Advanced Course of Renewable Energy Science					
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391560 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		English/ Japanese

[Outline and purpose]

The first half of this lecture overviews the status quo of renewable energies such as solar, wind, biomass, wave, ocean thermal and their conversion technologies, and examine their road map into the future. In the latter half is focused on biomass energy, and the details of its potential and its energy conversion technologies are examined.

[Objectives]

1) Understand the status quo of the renewable energy conversion technologies and their potential in the near future.
2) Understand technological details of biomass energy conversion and their application to bio-refinery.

[Requirements]

Knowledge on chemistry and physics at undergraduate level. Basic understanding of chemical thermodynamics.

[Evaluation]

Examination: midterm 50%, final 50%.

[Textbooks]

[References]

1. NEDO White Book on Renewable Energy Technology (in Japanese) (Downloadable from http://www.nedo.go.jp/library/ne_hakusyo_index.html)
2. 清水幸丸, 再生型自然エネルギー利用技術, パワー社, ISBN:978-4-8277-2267-3
3. 横山伸也、芋生憲司, バイオマスエネルギー, 森北出版, ISBN:978-4-627-94721-4
4. 木谷収, バイオマスー生物資源と環境ー, コロナ社, ISBN:978-4-339-06733-0

[Schedule]

1st - 7th week: The status quo of renewable energy (solar, wind, biomass, wave, ocean thermal, etc.) conversion technologies and their road map.
8th – 11th week: Potential of biomass energy and its energy conversion technologies.
12th – 15th week: Bio-refinery technologies and their applications.

[Title]			[Instructor]		
Advanced Course of System Engineering for Energy Storage			Tsuneji Kameda		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391570 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		Japanese

[Outline and purpose]

Renewable energy is thought to play an increasingly significant role in reducing the environmental load and reinforcing the energy securities. Concerning a promotion of the large amounts of fluctuating electricity from renewable energy into the grid, the electricity storage system is necessary in both meanings of load-leveling and demand- supply adjustment.

The energy storage technologies are reviewed in terms of cost efficiency, and some application examples are studied in this course.

[Objectives]

1. to understand the general view of the energy storage technologies, especially focused on the load-leveling and demand- supply adjustment of the renewable energy generation.
2. to study some actual approaches in the world.

[Requirements]

an interest and a basic knowledge for the renewable energy

[Evaluation]

final examination：100%

[Textbooks]

to be determined

[References]

「国家戦略会議」,「基本問題委員会」資料（2012 年 7 月 5 日）(in Japanese)、他

[Schedule]

1. Introduction
2. Technologies for energy storage
3. Technologies for energy transport
4. Electrical power storage systems
5. Renewable energy generation and power storage　part 1
6. Renewable energy generation and power storage　part 2
7. Specific case study
8. Summary

[Title]			[Instructor]		
Advanced Course of Science for Energy Materials			Tetsu Kiyobayashi		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391580 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	Intensive	／	English／Japanese

[Outline and purpose]

The energy materials mainly addressed in this intensive course are hydrogen storage materials and battery electrode materials. Physical chemistry lying behind these materials is dealt with.

[Objectives]

To acquire the knowledge on hydrogen storage materials and battery electrode materials

[Requirements]

General knowledge on physical chemistry in the undergraduate course

[Evaluation]

Attendance 60%
Report 40%

[Textbooks]

N.A.

[References]

N.A.

[Schedule]

1. Overview of hydrogen energy
2. Hydrogen storage technologoes
3. Physical chemistry of hydrogen storage materials
4. Hydrogen storage alloys, complex hydrides, carbons...
5. Problems and prospects
6. Materials in battery electrodes
7. Environmental issues
8. Summary

[Title]			[Instructor]		
Advanced Course of Chemistry for Solar Cells			Masatoshi Yanagida		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391590 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	Intensive	／	English／Japanese

[Outline and purpose]

Solar cells convert inexhaustible solar-light energy to electrical energy, being most promising renewable and sustainable energy. Solar cells are now prevailing as subsidized photovoltaic power plants in developed countries. However, solar cells should become prevailed as subsidiary-free and personalizing solar cells in near future. Such next generation solar cells must have not only high efficiency and long durability but also low cost efficiency and environment-friendliness. Basic knowledge of solar cells will be lectured to discuss about the next generation solar cells.

[Objectives]

An understanding of the basic mechanism of photovoltaics, and acquisition of the knowledge about a future subject of solar cells

[Requirements]

Basic knowledge about the electrochemistry and the physical chemistry which were learned in the undergraduate class

[Evaluation]

Homework & report：40%
Calculation & discussion on this lecture：60%

[Textbooks]

Power Point of Instructor

[References]

桑野幸徳：「太陽電池はどのように発明され、成長したのか」 ―太陽電池開発の歴史―、オーム社、2011 年 (in Japanese)

[Schedule]

1. Introduction of photovoltaics
2. Status of solar cells
3. Silicon based solar cells(single and ploy crystalline silicon solar cells)
4. Thin layered Si based solar cells
5. CIGS based solar cells
6. Dye-sensitized solar cells
7. Organic thin film solar cells
8. Other new photovoltaics (Quantum dot solar cells)

[Title]			[Instructor]		
Advanced Course of Applied Electrochemistry			Hiroshi Senoh		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391600 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		Japanese

[Outline and purpose]

The importance of electrochemistry is undeniable – we cannot live without electrochemistry. There are various applications of electrochemical systems, like battery, fuel cell, super capacitor, electroplating and sensor.

The purpose of this course is to consider the application of electrochemical system for green energy conversion science and technology.

[Objectives]

1. to understand the importance of electrochemical devices in our lives
2. to propose some methods for solving the environmental problem by the application of electrochemistry

[Requirements]

a grounding in chemistry, electricity and industry

[Evaluation]

examination : 50%
report : 50%

[Textbooks]

[References]

[Schedule]

1. Introduction - electrochemical devices
2. Corrosion and plating
3. Sensor with high sensitivity
4. Electrolysis to produce chemical substances
5. Battery as an energy storage
6. Approach for electric vehicle
7. Expectation of applied electrochemistry
8. Examination

[Title]			[Instructor]		
Advanced Course of Engineering for Electrode Nano-Materials			Yoshimi Kubo		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391610 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		English／Japanese

[Outline and purpose]

Structures and properties of nanocarbon materials will be reviewed in connection with electrodes of fuel cells and secondary batteries. Recent application of nanocarbons to the air electrode in lithium-air battery will also be discussed in detail.

[Objectives]

To acquire knowledge and understanding of structures and properties of nanocarbon materials used in fuel cells and secondary batteries. To acquire knowledge and understanding of the principle and structure of lithium-air secondary battery as well as current status of the technology.

[Requirements]

Undergraduate level of physics, chemistry and electrochemistry

[Evaluation]

-Class attendance (50%)
-Report (50%)

[Textbooks]

None

[References]

None

[Schedule]

1. Introduction to nanocarbon materials
2. Structures and properties of nanocarbon materials
3. Application of nanocarbons to batteries and fuel cells
4. Introduction to lithium-air secondary battery
5. Electrochemistry of lithium-air secondary battery
6. Comparison of lithium-air battery and fuel cells
7. Structural design of air electrodes
8. Promise and challenges of lithium-air secondary battery

[Title]			[Instructor]		
Advanced Course of English for Green Energy Science and Technology, Advanced Level			D. A. Tryk / M. E. Brito		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391810 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology	1st Semester	Wed.／III	English／Japanese

[Outline and purpose]

This course will cover reading, writing, speaking and listening for scientific and engineering English, including special emphasis on green energy and technology. Presentation and discussion skills will be particularly emphasized, as well as writing and literature search skills.

[Objectives]

The specific achievements or milestones will include: (1) ability to read a technical paper and summarize it briefly in English; (2) ability to write a short paper; (3) ability to confidently give a short technical presentation in English; (4) ability to listen to an oral technical presentation and ask relevant questions.

[Requirements]

D1 status

[Evaluation]

Attendance: 20%; presentations: 40%; reports: 40%

[Textbooks]

None

[References]

None

[Schedule]

1. Introduction; overview; basic pronunciation; "Tell Me More" online software;
2. Pronunciation of general chemical terms, specific terms for your research theme; self-introductions 1;
3. Self-introductions 2;
4. Introduction of your hobby, special interests, English study methods 1;
5. Introduction of your hobby, special interests, English study methods 2;
6. "Tell Me More" online software;
7. Brief reports on papers (from the literature) related to your research 1;
8. Brief reports on papers (from the literature) related to your research 2;
9. Brief version of oral research presentation 1;
10. Brief version of oral research presentation 2;
11. "Tell Me More" online software;
12. Final oral presentations 1;
13. Final oral presentations 2;
14. Final oral presentations 3;
15. Final oral presentations 4.

[Title]			[Instructor]		
Advanced Course of Innovation Management			Hiroshi Osada		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391710 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		Japanese

[Outline and purpose]

To understand an indispensable innovation to the sustainable growth for Japanese manufacturing industry in global economy is expected. Especially management necessary to align product/business and technological development by the innovation and to accomplish the development of business is studied through the case. Moreover, the methodology of such innovation management is acquired

[Objectives]

The content of Management of Technology (MOT) to develop the product and business by innovation is understood, and the management methodology of planning and developing new products is studied
In addition, the method of how to advance the group discussion and presentation is learnt through the case study.

[Requirements]

No preliminary knowledge on management and the innovation is needed.

[Evaluation]

Attendance(20) , One Report(50), Discussion and Presentation by group work(30) : Total Score(100)

[Textbooks]

Akio Yamanouchi "New Management of Technology", Nikkei News Paper(1992) ISBN:4-532-13015-8
Hiroshi Osada ed. " Strategic Management by Policy in TQM Age", JUSE(1996) ISBN:4-8171-0288-8

[References]

Hirshi Osad "Best Practice Company", JUSE(2003) ISBN:4-8171-0100-8
Hiroshi Osada ed. " Self Assessment of Management System" ,JSA(2001) ISBN:978-4-542-70138-0
Hiroshi Osada ed. " Innovative Problem Solving Method", JUSE(2011) ISBN:978-4-8171-9410-7

[Schedule]

(1) Introduction to Innovation
(2) Management of development of Technology, product and business
(3) Case study 1: Innovation by Linear motion system of THK Co .Ltd (Explanation and DVD)
(4) Case study 2: Group exercise- Analysis and discussion
(5) Case study 3: Group exercise- Making presentation material and preparation for presentation
(6) Case study 4: Group exercise- Presentation by group and discussion, Wrapping up
(7) Management of dissemination of new products in the market
(8) Strategic planning and operations management, Wrapping up

[Title]			[Instructor]		
Advanced Course of Engineering Ethics			Kazutoshi Higashiyama / M. E. Brito		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391720 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		Japanese

[Outline and purpose]

Ethics is indispensable not only to form and keep good human relationship but also to create and protect sustainable global environment. The aim of this course is to learn about basic of ethics, why the ethics is important for scientist and engineer and current society regulations we have to learn.

[Objectives]

To be a high-principled global engineer in the field of materials science.

[Requirements]

Not needed.

[Evaluation]

Attendance, understanding, test and report.

[Textbooks]

「Basic of ethics for engineer」 by Y. Sugimoto and S. Takagi, Maruzen Press
ISBN978-4-621-08029-0

[References]

E.G.Seebauer and R.L.Barry 「Fundamentals of Ethics for Scientists and Engineers」

[Schedule]

1. What is ethics?
2. Moral, ethics and law
3. History of ethics
4. Ethics in engineering
5. Engineer's duty to society
6. Learn from the past
7. Code of ethics in industry
8. Importance of compliance

[Title]			[Instructor]		
Advanced Course of Economics for Energy and Environment			Hisaaki Gyoten		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391730 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	Intensive	／	Japanese

[Outline and purpose]

Under the growing interest in global environmental issues, the new energy technologies such as fuel cells, solar cells, thermoelectric elements, energy management technology, or the environmental technologies such as purification technology, green technology, are expected as core technologies which could solve those issues. In this lecture, present status of those technologies will be explained briefly. At the final part, we will think together about how to contribute to the establishment of the sustainable future society by the full use and fusion of those technologies.

[Objectives]

In addition to acquire the basic knowledge about the each environmental energy technologies, the ability to envision the ideal future society with strong ambitions should be cultivated.

[Requirements]

Basic knowledge regarding to energy conversion, such as physical chemistry and semiconductor physics learned in undergraduate

[Evaluation]

Attendance and participation to discussion (40%): evaluated by comprehension of lecture and daily efforts.
Short test and report (60%):evaluated by the ability to extract the essential issue and to solve them through theoretical thinking. The ability to describe your own opinions and persuade others also required.

[Textbooks]

non

[References]

non

[Schedule]

(1)Introduction to Energy Technology
1. Fuel Cell(No1, No2)
2.Solar Cells (No1,No2)
3.Thermoelectric Elements
4.Other Energy Technologies (No1, No2)
(2)Introduction to Environmental Technologies
1.Purification Technology (No1, No2)
(3)Recent Topics(No1, No2)
(4)Discussions (how to contribute the establishment of sustainable future society)
(5)Summary and Evaluation

[Title]			[Instructor]		
Advanced Course of Science and Technology			Akihiro Iiyama		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391740 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	Intensive	／	English／Japanese

[Outline and purpose]

Automobile has been developed by applying advanced technology. Currently to respond to energy and environmental issues, the wave of electrification has come, such as Battery EV, HEV,PHEV and FCEV. This course is to introduce current status and future issues on those advanced technology application to automobiles.

[Objectives]

To get understanding and knowledge on the application of advanced science and technology into automotives, especially fuel cell.

[Requirements]

Undergraduate level of electrochemistry.

[Evaluation]

40%; Report (Competency for logical thinking, task setting, and task solving)
60%; Class attendance (Competency of understanding and daily efforts)

[Textbooks]

None

[References]

None

[Schedule]

No.1 ; Circumstances of Automobile (History, Future perspectives, Energy trend)
No.2 ; Safety technology for Automobile
No.3 ; Environmental technology for Automobile
Development history and issues
Internal Combustion Engine vehicle
No.4 : Battery Electric Vehicles
No.5 ; FuelCell Electric Vehicles
No.6 ; Fuel Cell Technology
History of development and application
Features of FC for automobile
No.7 ; Structure and Parts of Fuel Cell
Code and Standard trend
No.8 : Issues for commercialization of FCEV
And summary

[Title]			[Instructor]		
Advanced Course of International Standardization			Atsushi Ohma		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391750 D	1	Special Doctoral Program for Green Energy Conversion Science and Technology	This subject isn't offered.		English／Japanese

[Outline and purpose]

Currently, the wave of electrification has come in automobiles such as Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in HEV, and Fuel Cell Electric Vehicle (FCEV), and they are in the worldwide development competition. This course is to introduce the purpose of international standardization, current status of BEV and FCEV development and activity for the standardization, and future challenges.

[Objectives]

To get understanding and knowledge on the purpose of international standardization, activity of the standardization in automobiles, current status of BEV and FCEV development, and standardization related to LiB and PEFC.

[Requirements]

Undergraduate level of electrochemistry and chemical engineering.

[Evaluation]

40%; Report (Competency for logical thinking, task setting, and task solving)
60%; Class attendance (Competency of understanding and daily efforts)

[Textbooks]

None

[References]

http://fccj.jp/jp/information.html#data

[Schedule]

No.1 ; What is International Standardization?
No.2 ; Circumstances of Automobile and Standardization
No.3 ; Current Status of Battery Electric Vehicle Development
No.4 ; Lithium-ion Battery and Standardization
No.5 ; Current Status of Development Fuel Cell Electric Vehicle Development
No.6 ; Polymer Electrolyte Fuel Cell Stack, Membrane Electrode Assembly and Materials, and Standardization
No.7 ; Hydrogen Technology and Standardization
No.8 ; Future Challenges and Summary

[Title]			[Instructor]		
Advanced Exercises for Green Energy Engineering I			Each staff		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391900 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology		Fri.／II	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.
・Open forums are held where students try their skills with their opponents from other institutes, faculty or students from different fields, with the aim of expansion of their point of view and improvement of their debate skills.

[Title]			[Instructor]		
Advanced Exercises for Green Energy Engineering I			Each staff		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391900 E	2	Special Doctoral Program for Green Energy Conversion Science and Technology		Fri.／II	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.
・Open forums are held where students try their skills with their opponents from other institutes, faculty or students from different fields, with the aim of expansion of their point of view and improvement of their debate skills.

[Title]			[Instructor]		
Advanced Exercises for Green Energy Engineering II			Each staff		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391910 D	2	Special Doctoral Program for Green Energy Conversion Science and Technology		Fri.／III	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.
・Open forums are held where students try their skills with their opponents from other institutes, faculty or students from different fields, with the aim of expansion of their point of view and improvement of their debate skills.

[Title]			[Instructor]		
Advanced Exercises for Green Energy Engineering II			Each staff		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
391910 E	2	Special Doctoral Program for Green Energy Conversion Science and Technology		Fri.／III	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology. For this purpose, students have opportunities to present the results of their studies in monthly research meetings.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.
・Open forums are held where students try their skills with their opponents from other institutes, faculty or students from different fields, with the aim of expansion of their point of view and improvement of their debate skills.
・Qualifying examination