[Title]			[Instructor]		
Advanced Condensed Matter Physics			Akira Ishikawa/ Atsushi Shohji		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ501	2	Advanced Material Science	1st Semester	Mon./II	Japanese/English

[Outline and purpose]

This course, which is based on electrodynamics, quantum mechanics, statistical mechanics, and condensed matter physics, deals with thermal-equilibrium and nonequilibrium statistical physics and magnetic phenomena in solid-state materials. The essence of the theories and experiments will be systematically lectured for deeper understanding of solid state materials.

[Objectives]

1. to understand the concept of ensembles in quantum statistical mechanics
2. to understand the phase transition and phase separation
3. to understand the linear response theory and Boltzmann equation
4. to understand magnetic response of materials
5. to understand spin and exchange interaction
6. to understand spin-orbital interaction

[Requirements]

electrodynamics, quantum mechanics, solid state physics, statistical mechanics

[Evaluation]

homework/examination : 100 %

[Textbooks]

[References]

Morikazu Toda and Ryogo Kubo, Statistical Physics I, II (Springer, ISBN: 9783540536628)

[Schedule]

1. Statistical mechanics and quantum mechanics (A. Ishikawa)
2. Quantum statistical mechanics (A. Ishikawa)
3. Phase transition and phase separation in spin systems (A. Ishikawa)
4. Ginzburg-Landau theory (A. Ishikawa)
5. Boltzmann equation (A. Ishikawa)
6. Linear response theory (A. Ishikawa)
7. Nonequilibrium dynamics (A. Ishikawa)
8. Magnetic material and magnetic moment (A. Shohji)
9. Exchange interaction (A. Shohji)
10. Paramagnetism of ionic crystals (A. Shohji)
11. Ferromagnetism (A. Shohji)
12. Diamagnetism and ferrimagnetism (A. Shohji)
13. Magnetism of metal (A. Shohji)
14. Magnetic materials and their applications (A. Shohji)
15. Summary of condensed matter physics

[Title]			[Instructor]		
Advanced Quantum Devices			Hirokazu Hori/ Keisuke Arimoto/ Kazuharu Uchiyama		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ502	2	Advanced Material Science	2st Semester	Thu.／Ⅱ	Japanese

[Outline and purpose]

In this program, bases of quantum mechanics and solid state physics are summarized, and then principles of devices which utilize quantum effects (e.g. semiconductor heterostructure devices) are lectured. The physical and engineering bases are provided for analysis and design of functionalities in novel devices and systems based on the interdisciplinary sciences of electronic and electromagnetic dynamics including quantum mechanical features through transport of signal and information in non-equilibrium open system as well as the underlying fundamental processes.

[Objectives]

Obtaining knowledge of the following items is the objective of this program.
(1) Fundamentals of quantum mechanics (e.g. states of electrons confined in quantum wells)
(2) Principles of functionality based on interaction in nanostructured devices including local environment

[Requirements]

Basic knowledges about quantum mechanics and solid-state physics are desirable.

[Evaluation]

Level of understanding is evaluated by small tests, reports and term-end examination.

[Textbooks]

[References]

Jasprit Singh, “Electronic and Optoelectronic Properties of Semiconductor Structures” (Cambridge University Press)

[Schedule]

1 Basics of quantum mechanics and classical/quantum statistical mechanics
2 Electronic states in solids
3 Quantum size effect
4 Band structure
5 Electron and current densities in nano-structures
6 Effective mass approximation
7 Transition probability and optical properties (absorption/emission) of materials
8 Phenomena and observations as the basis of functionality
9 Construction of quantum mechanical functionality
10 Thermodynamics basis for transport processes in non-equilibrium open system
11 Dynamics of environment as the basis of functionality
12 Phenomenology and mathematics for functionalities
13 Quantum optical devices based on laser and optical processes
14 Optoelectronics devices and quantum mechanical features
15 Summary and assessment

[Title]					
Advanced Photonics			Tetsuo Harimoto / Masaru Sakai		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ503	2	Advanced Material Science	1st Semester	Fri.／II	Japanese

[Outline and purpose]

To pursue understanding of optics and related basic principles investigated with optoelectronics and optical devices.

[Objectives]

To acquire following basic knowledge of optics and photonics as they relate to forefront research of novel opto- and photo-electronic devices.
(1) Wave-particle duality of light
(2) Propagation, interference, and diffraction of light
(3) Optical semiconductors
(4) Nonlinear optics
(5) Basic principles of the laser

[Requirements]

Wave theory, Electromagnetics, Elementary quantum mechanics, Mathematics.

[Evaluation]

Homework / Examination : 80%
Audit attitude : 20%

[Textbooks]

[References]

1. A. Yariv, Photonics: Optical Electronics in Modern Communication, Oxford Univ. Pr., ISBN: 0195179463
2. A. Furusawa, Quantum optics and quantum information science, Saiensu-sha Co., Ltd. Publishers, ISBN:4901683233 (in Japanese)
3. M. Matsuoka, Quantum Optics, Shokabo Co., Ltd., ISBN:4785320935 (in Japanese)

[Schedule]

1. Wave-particle duality of light
2. Polarization of light and polarization conversion
3. Gaussian beam optics
4. Total internal reflection and evanescent field
5. Electron-photon interactions I
6. Electron-photon interactions II
7. Numerical calculations in optics
8. Basic laser principles
9. Generation of ultrashort laser pulses
10. Amplification of lasers
11. Control and detection of ultrashort and high intensity laser beams
12. Lasers devices: laser diode, all-solid-state lasers, and high-power lasers
13. Applied laser technologies: high-accuracy measurement and nanotechnology
14. Applied laser technologies: fine processing and nuclear fusion
15. Summary and assessment

[Title]			[Instructor]		
Advanced Quantum Material Science			Eiichi Kondoh / Tetsuya Sato/ Kazuya Ogawa		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ505	2	Advanced Material Science	1st Semester	Thu.／II	Japanese/English

[Outline and purpose]

This course deals with fabrication of thin films and nanomaterials, properties and characteristics of organic electronic/photonic materials, and gas-based microfabrication technologies including lithography as well as property changes upon miniaturization. The contents cover dye sensitized solar cell and organic nonlinear optical materials, organic - chemistry theories for synthesizing these materials and photochemistry as the basis for material characterization, and fabrication and testing for electronic/photoelectronic devices.

[Objectives]

1. to understand the fundamentals for microfabrication
2. to understand the fundamental principles of plasma discharges
3. to understand the gas- and surface-phase chemical reactions
4. to understand the principles of dye sensitized solar cell and organic NLO materials

[Requirements]

Physical Chemistry, Quantum Chemistry, Electromagnetism

[Evaluation]

examination : 25 %
homework : 25 %
audit attitude : 25 %
presentation : 25 %

[Textbooks]

[References]

1) The science and engineering of microelectronic fabrication, S. A. Campbell, Oxford, ISBN-10: 0195136055
2) Michael A. Lieberman, *Principles of Plasma Discharges and Materials Processing, 2nd Edition,* Wiley-Inter science , ISBN: 978-0-471-72001-0

[Schedule]

1. Microfabrication using gases
2. Gas kinetics
3. Thin film and evaporation
4. Etching
5. Lithography
6. What is discharges and plasma?
7. Principles of plasma discharges
8. Interaction of the plasma and the solid surface
9. Fabrication of thin films and nanostructure using plasma processes
10. Characterization of thin films and nanostructure
11. Introduction to organic functional materials
12. Organic nonlinear optics 1　Optical Kerr effect
13. Organic nonlinear optics 2　two-photon absorption
14. Dye sensitized solar cell
15. Assessment and explanation

[Title]			[Instructor]		
Advanced Functional Materials			Nobuhiro Kumada / Isao Tanaka / Takahiro Takei/ Eiichi Kondoh		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ506	2	Advanced Material Science	2nd Semester	Tue.／I	English／Japanese

[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. For various synthesis processes, the mechanism and their theories are acquired.

[Objectives]

1. to understand relationship between defect concentration and physical properties by lattice defect formation in crystalline materials
2. to understand techniques of crystal structure analysis
3. to understand formation mechanism in various synthesis processes for solid state materials
4. to gain ability to use binary phase diagrams

[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, Solid State Chemistry and Its Applications, Second Edition, JOHN WILEY & SONS, LTD, ISBN:978-1-119-94294-8

[References]

[Schedule]

1. Function and property by crystal defects
2. Non-stoichiometry and lattice defects in oxides
3. Defect concentration and defect equilibrium
4. Relationship between defect concentration and electrical conductivity
5. Fundamentals of crystal chemistry
6. Fundamentals of X-ray crystal structure analysis
7. Application of X-ray powder diffraction I
8. Application of X-ray powder diffraction II
9. Synthesis of inorganic materials by solid state reaction
10. Sol-gel synthesis of inorganic materials
11. Synthesis by hydrothermal and solvothermal reactions
12. Thin film preparation by gas phase reaction
13. Solid-liquid interface
14. Phase diagram and microstructures
15. Microstructures of solidifying grains. Summary

[Title]			[Instructor]		
Structure and Chemistry of Crystalline Solids			Junji Yamanaka / Satoshi Watauchi / Yonezaki Yoshinori		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ507	2	Advanced Material Science	2st Semester	Thu./II	Japanese/English

[Outline and purpose]

There are three important purposes in this lecture:
1. For a better understanding of physical properties of crystals, the concepts of symmetry operations are lectured from the viewpoint of group theory.
2. To investigate physical properties of crystals, a bulk crystal is very useful. The concepts of nucleation mechanism are also lectured.
3. We will also learn reciprocal space, electron diffraction, and transmission electron microscopy.

[Objectives]

To image structural features from point group notations
To understand the nucleation mechanism based on the thermodynamics
Comprehension of electron diffraction.

[Requirements]

Basic knowledge on physical chemistry and solid state chemistry.
Completion of undergraduate course covering basic physics.
Completion of undergraduate course covering basic chemistry.

[Evaluation]

Examinations: 80%
Reports (homework) & mini-exam. : 20%

[Textbooks]

[References]

Basic Solid State Chemistry Second Edition, WILEY (ISBN: 0471987565)
Transmission Electron Microscopy, A Textbook for Materials Science, Springer Science+Business Media, 2009, (ISBN: 978-0-387-76502-0)

[Schedule]

1 Application of group theory to crystallography, Sets
2 Groups
3 Symmetry elements and Symmetry operations
4 Lattice, space groups
5 Phase equilibria
6 Nucleation
7 Surface energy
8 Equilibrium shape of crystal
9 Principle of growth
10 X-ray diffraction and electron diffraction
11 Reciprocal space and electron diffraction
12 Basic Mechanical Structure of TEM
13 Practical use of TEM for inorganic materials
14 Recent topics about TEM
15 Examinations and commentaries

[Title]			[Instructor]		
Advanced Special Lectures I					
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ601	1	Advanced Material Science	Intensive	／	Japanese

[Outline and purpose]

The lecture indicates the state of the art of material science.

[Objectives]

To acquire the interdisciplinary knowledge on material science based on the knowledge of science in the undergraduate level

[Requirements]

The basic knowledge of material science for the undergraduate level

[Evaluation]

Presentation or report 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

The lecture contents will be announced through the Campus Networking System (CNS).

[Title]			[Instructor]		
Advanced Special Lectures II					
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ602	1	Advanced Material Science	Intensive	／	Japanese

[Outline and purpose]

The lecture indicates the state of the art of material science.

[Objectives]

To acquire the interdisciplinary knowledge on material science based on the knowledge of science in the undergraduate level

[Requirements]

The basic knowledge of material science for the undergraduate level

[Evaluation]

Presentation or report 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

The lecture contents will be announced through the Campus Networking System (CNS).

[Title]			[Instructor]		
Seminar in Advanced Material Science IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ603	1	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]					
Seminar in Advanced Material Science IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ604	1	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Seminar in Advanced Material Science IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ605	1	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field in addition to the Seminar I. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Seminar in Advanced Material Science IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ606	1	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field in addition to the Seminar I. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ607	2	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master’s thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ608	2	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master’s thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ609	2	Advanced Material Science	1st Semester		English／Japanese

[Outline and purpose]

Research studies on advanced material science for master’s thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ610	2	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master’s thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation：100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates