| 科目コード (Code) | 科目名 (Course title) | Course title (English) |
|---|---|---|
| 10C710 | 電子工学特別実験及演習１ | Advanced Experiments and Exercisesin Electronic Science and Engineering I |
| 10C713 | 電子工学特別実験及演習２ | Advanced Experiments and Exercisesin Electronic Science and Engineering II |
| 10C825 | 量子論電子工学 | Quantum Theory for Electronics |
| 10C800 | 半導体ナノスピントロニクス | Semiconductor Nanospintronics |
| 10C801 | 電子装置特論 | Charged Particle Beam Apparatus |
| 10C803 | 量子情報科学 | Quantum Information Science |
| 10C810 | 半導体工学特論 | Semiconductor Engineering, Adv. |
| 10C813 | 電子材料学特論 | Electronic Materials, Adv. |
| 10C816 | 分子エレクトロニクス | Molecular Electronics |
| 10C819 | 表面電子物性工学 | Surface Electronic Properties |
| 10C822 | 光物性工学 | Optical Properties and Engineering |
| 10C828 | 光量子デバイス工学 | Quantum Optoelectronics Devices |
| 10C830 | 量子計測工学 | Quantum measurement |
| 10C851 | 電気伝導 | Electrical Conduction in Condensed Matter |
| 693631 | 集積回路工学特論 | Integrated Circuits Engineering, Adv. |
| 10X001 | 融合光･電子科学の展望 | Prospects of Interdisciplinary Photonics and Electronics |
| 10C846 | 電子工学特別研修１(インターン) | Advanced Seminar in Electronic Science and Engineering I |
| 10C848 | 電子工学特別研修２(インターン) | Advanced Seminar in Electronic Science and Engineering II |

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 電子工学特別実験及演習１<br>Advanced Experiments and Exercises in Electronic Science and Engineering I | | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU | |
| Target year | | Number of credits | 4 | Course offered year/period | 2019/Intensive, year-round |
| Day/period | Intensive | Class style | Experiment | Language | Japanese |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,30times,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 電子工学特別実験及演習２<br>Advanced Experiments and Exercises in Electronic Science and Engineering II | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU | | |
| Target year | | Number of credits | 4 | Course offered year/period | 2019/Intensive, year-round |
| Day/period | Intensive | Class style | Experiment | Language | Japanese |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,30times,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.

| Numbering code | | | |
|---|---|---|---|
| Course title <English> | 量子論電子工学<br>Quantum Theory for Electronics | Affiliated department, Job title,Name | Graduate School of Engineering<br>Associate Professor,KAKEYA ITSUHIRO |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Tue.3 | Class style | Lecture | Language | Japanese |

**[Outline and Purpose of the Course]**

Based on the fundamental understanding of quantum mechanics, we start with hydrogen atom of 1 atom and 1 hydrogen atom, hydrogen molecule ion of 2 atom electrons, hydrogen molecule of 2 atom 2 electrons, 1 electron Lecture on how to calculate the electronic state when increasing the number from the next step. We will also talk about molecular models consisting of a plurality of atoms. In order to understand fundamental handling in the case of multi electron system, consider Coulomb interaction, spin orbit interaction, as an interaction received by electrons. Simultaneously, we give an approximate calculation method necessary for these calculations.

**[Course Goals]**

Based on the fundamental understanding of quantum mechanics, we acquire knowledge and thinking to the extent that approximate calculation can be performed on a simple problem. In addition, we will acquire academic ability to read only specialized books such as solid state electronics based on quantum theory.

**[Course Schedule and Contents]**

Review and supplement of quantum mechanics (1 time)
Review the quantum mechanics learned at undergraduate and repair notation method to learn from now.

Approximation method (2 times)
Perturbation method, perturbation method when degenerate, time dependent perturbation method, variational method, learn while solving exercises. The approximation method learned here becomes the basis of the calculation concerning the contents of the subsequent lecture.

Combined with angular momentum (2 times)
We describe the angular momentum necessary for understanding the electronic level and its composition.

Spin orbit interaction (1 time)
Understanding the spin orbit interaction is essential for understanding the details of the electronic level of multiple electron atoms and the electronic level in solids. Here, I will give lectures and descriptions of spin orbit interactions and explain quantitative handling methods. Explain calculation by perturbation method and calculation by diagonal method.

Multiplet (1 time)
I will give a lecture on the electronic level of multiple electron atoms. In particular, we will clarify the origin of microstructure and understand how electron level is split by Coulomb interaction, spin orbit interaction, its magnitude and number of divisions. In addition, we describe empirical Hunt 's law concerning the ground state of such multi - electron atoms.

Zeeman effect (2 times)

Continue to 量子論電子工学(2)↓↓↓

## 量子論電子工学(2)

The shift of the electronic level in the magnetic field or Zeeman splitting will be explained by calculation by the perturbation method. Abnormal Zeeman effect when the magnetic field is weak, normal Zeeman effect, Paschen back effect in case of strong, handling of spin orbit interaction will be discussed.

Hartree-Fock equation (2 times)
We describe the calculation of electronic levels of multi-electron atoms about the Hartley method, the Hartley-Fock method, and the Hartree-Fock-Slater method by mean field self-consistent method.

Molecular model (2 times)
In the case of bimolecular molecules, we will explain the valence bonding method and the molecular orbital method, and explain the hydrogen level, the electronic level of hydrogen molecule, that is, the binding energy and the bonding distance. Also, we will talk about the type of molecular bond and hybrid trajectory.

Crystal field and magnetism (2 times)
The electron orbit of the atom in the crystal will be explained from the crystal electric field. In addition, we introduce Heisenberg's effective Hamiltonian and outline the paramagnetism and electronic correlation of the substance.

### [Class requirement]

Basics of quantum mechanics (Schrodinger equation, one dimensional potential problem, concept of expectation, etc.)

### [Method, Point of view, and Attainment levels of Evaluation]

Examination and report

### [Textbook]

Instructed during class

### [Reference books, etc.]

**（Reference books）**

Introduced during class

### [Regarding studies out of class (preparation and review)]

Please do exercises voluntarily

### （Others (office hour, etc.) ）

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course title <English> | 半導体ナノスピントロニクス<br>Semiconductor Nanospintronics | | | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,SHIRAISHI MASASHI | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/Second semester | | |
| Day/period | Tue.2 | Class style | Lecture | Language | Japanese and English | | |

## [Outline and Purpose of the Course]

Spintronics is now attracting tremendous attention, and is recognized as one of the most potential candidates to overcome the limit of the Moore's law. Spintronics possesses attractive and profound basis physics and also a potential to practical applications towards MRAMs and spin FETs. In this lecture, I introduce some important and basic theories and experimental techniques in spintronics using semiconductors, metals, insulators, oxides and so on.

## [Course Goals]

Understanding basic physics of spin transport, spin current and spin-orbit coupling. Mastering calculation skills related with these topics.

## [Course Schedule and Contents]

Introduction,1time,Spin is a quantum quantity, and thus it is to induced by rotation of an electron (an electron is an elementary particle, i.e., it has no domain. Thus, rotation of an electron cannot be defined). Nevertheless, the spin degree of freedom can be coupled to spatial rotation because spin is a generator of infinitesimal rotation. I explain the essence of spin, its SU(2) algebra and so on.
Relativistic quantum physics and spin-orbit interaction,5times,To understand spin manipulation and spin coherence in semiconductor, it is quite important what the spin-orbit interaction (SOI) is. The SOI is a manifestation of a relativistic effect, and the Dirac equation, the equation of motion in relativistic quantum physics, is derived to understand the SOI. Next, the SOI is explicitly derived be expanding the Dirac equation. As a related important topic, electron motion in graphene, which can be described as massless Dirac fermion, and the Berry phase (a geometric phase that plays an important role in spintronics) of electrons in graphene are discussed.
Electrical and dynamical spin injection into condensed matters and generation of pure spin current ,5-6times, Pure spin current is a quite significant physical current in spintronics using semiconductors and so on. Pure spin current is a current of only a spin degree of freedom without a net charge flow. I introduced some important papers and show how to derive essential equations describing generation and propagation of pure spin current. (1) Spin drift-diffusion equation, (2) Hanle-type spin precession, (3) spin pumping using magnetization dynamics, and (4) spin current circuit theory are discussed.
Recent topics in spintronics,2-3times,Topological insulators and the Berry phase are important topics in modern spintronics. To understand the essence of them, I show the derivation of the Kubo formula, and the calculation of the Hall conductivity based on the Kubo theory. The above mentioned topics are the main contents of this lecture, but I may add or omit some topics as requests from students.

Continue to 半導体ナノスピントロニクス(2)↓↓↓

## 半導体ナノスピントロニクス(2)

### [Class requirement]

Solid State Physics and Quantum Physics at the level of undergraduate school.

### [Method, Point of view, and Attainment levels of Evaluation]

Report submission

### [Textbook]

None

### [Reference books, etc.]

**（Reference books）**

For foreign students, I recommend the following review articles: 1. Spin Hall effect, J. Sinova et al., Rev. Mod. Phys. 87, 1213 (2015). 2. Spintronics: Fundamentals and applications, I. Zutic et al., Rev. Mod. Phys. 76, 1 (2004). 3. Nonlocal magnetization dynamics in ferromagnetic heterostructures, Y. Tserkovnyak et al., Rev. Mod. Phys. 77, 1375 (2005).

### [Regarding studies out of class (preparation and review)]

### （Others (office hour, etc.)）

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course title <English> | 電子装置特論<br>Charged Particle Beam Apparatus | | | Affiliated department, Job title,Name | Graduate School of Engineering<br>Associate Professor,GOTOU YASUHITO | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/Second semester | | |
| Day/period | Wed.4 | Class style | Lecture | Language | Japanese | | |

## [Outline and Purpose of the Course]

Fundamental technologies of an ion beam system, such as ion sources, formation and evaluation of ion beams, transport of ion beams, and ion-solid interaction will be presented. Taking ion implantation as one of the example of the ion beam application, the relationship between the incident ion energy and implantation depth will be presented. Each element of a typical ion beam system is explained in detail.

## [Course Goals]

To understand the details of an ion beam apparatus: generation, transport and evaluation of an ion beam. Understanding of the entire ion beam apparatus as a system is also purpose of the class.

## [Course Schedule and Contents]

[Ion beam systems and their applications] Once
Outline of the class is presented. Physical properties of ions in vacuum are given, and ion beam apparatuses and their application will be introduced with some typical examples.

[Ion-solid interaction] 3 times
Interaction between high energy ion and solid atoms are given. Major topics are: how the ions transfer their energy to the target atoms, i.e., how the ions are decelerated in the solid, and relationship between incident ion energy and implantation depth is given. Concept of sputtering phenomenon is also presented.

[Nature of ion beam] Twice
Concept of the acceleration voltage is introduced to explain the principle of the ion beam systems. Nature of an ion beam is also presented.

[Generation and transport of ion beam] 3 times
Methods of ion generation for various elements are explained. Important equations of beam extraction and beam transport are given. Starting with the paraxial ray equation, concept of transfer matrix is given. Finally, some important physical parameters of ion beams are given.

[Mass separators and energy analyzers] 3 times
Details of magnetic sector as mass separator are given. Transfer matrix of the mass separator are presented and focusing effect is described. An important parameter of mass resolution is given. Some different kinds of energy analyzers are also introduced. Deflection and detection systems are also introduced.

[Fundamentals of vacuum engineering] Once
Fundamentals of vacuum engineering is given. Several pumps used for ion beam systems are also introduced.

[Design of ion beam systems] Once
Design of an ion beam system under a given condition will be presented.

Continue to 電子装置特論(2)↓↓↓

## 電子装置特論(2)

[Feedback] Once
In the last class, achievement test will be performed.

### [Class requirement]

Vacuum Electronic Engineering (undergraduate course)

### [Method, Point of view, and Attainment levels of Evaluation]

Grading will be made with the results of the term-end examination. Achievements of exercises in the class are also taken into consideration.

### [Textbook]

Yasuhito Gotoh, Charged Particle Beam Appratus, 2018 version (to be sold at CO-OP shop in Katsura Campus)

### [Reference books, etc.]

**（Reference books）**

Zyunzo Ishikawa 『Charged Particle Beams』 （Corona）ISBN:978-4-339-00734-3

### [Regarding studies out of class (preparation and review)]

### （Others (office hour, etc.) ）

We will have brief practice in each class. Bring your calculator and A4-size writing papers.

*Please visit KULASIS to find out about office hours.

| Numbering code | | | |
|---|---|---|---|
| Course title <English> | 量子情報科学<br>Quantum Information Science | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,TAKEUCHI SHIGEKI<br>Graduate School of Engineering<br>Associate Professor,OKAMOTO RYOU |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Mon.3 | Class style | Lecture | Language | Japanese and English |

**[Outline and Purpose of the Course]**

An overview of the quantum information sciences will be given. The topics includes the basic picture of wave/particle duality, quantum key distribution, quantum computation, quantum communication, quantum measurements.

**[Course Goals]**

To understand the basic concepts/mechanisms of quantum key distribution, quantum computers, and quantum metrology so that one can read and understand the scientific papers of the related area.

**[Course Schedule and Contents]**

Introduction, 3 times,
First, we outline the whole lecture and then explain basic concepts such as quantum bit, quantum gate, quantum entanglement etc.

Quantum Computer (Theory), 3 times,
On quantum computation, various quantum algorithms are discussed.

Quantum Computer (Experiment),3 times,
Quantum information processing is being studied in various physical systems such as photon, ion trap, nuclear spin and the like. We will explain how to realize them.

Quantum Key distribution and Quantum metrology,4 times,
Describe the basic concept of quantum cryptography and quantum measurements and their recent research trends.

Summary and Outlook, 2 times,
In addition to summarizing the whole, if time permits, discuss the problems of quantum information science and ethics.

**[Class requirement]**

Basic understanding of quantum mechanics will be helpful.

**[Method, Point of view, and Attainment levels of Evaluation]**

The number of days one has attended, and the score of reports will be considered.

**[Textbook]**

No text book will be used.

Continue to 量子情報科学(2)↓↓↓

**量子情報科学(2)**

**[Reference books, etc.]**

**（Reference books）**

Nielsen & Chuang, Quantum Computation and Quantum Information, Cambridge University Press

Shigeki Takeuchi, Quantum Computer, Kodansha (in Japanese)

**[Regarding studies out of class (preparation and review)]**

The reports are mandatory.

**（Others (office hour, etc.) ）**

We welcome your positive questions and comments. We select the language (Japanese or English) used in the lectureb taking into account the situation and hope of the students taking this lecture.

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | |
|---|---|

| Course title <English> | 半導体工学特論<br>Semiconductor Engineering, Adv. | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU |
|---|---|---|---|

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Wed.3 | Class style | Lecture | Language | Japanese |

**[Outline and Purpose of the Course]**

This course explores the fundamentals of semiconductor physics and engineering, which are esseantial to understand semiconductor materials and devices.

**[Course Goals]**

**[Course Schedule and Contents]**

Band theory,2-3times,Electronic band structures are discussed. Nearly free electron and tight-binding approachs are explained. Band structures of major semiconductors such as Si and GaAs are also discussed.
Carrier transport and scattering,3-4times,Carrier transport and electrical conduction are explained by using the Boltzmann transport equation. Scattering mechanism of carriers and mobility are discussed.
High-field effect,2-3times,Drift of carriers and junction breakdown under high electric field are discussed. A few phenomena under high magnetic field are also explained.
Defects in semiconductors,1-2times,Crystallographic and electronic properties of defects (both extended and point defects) in a semiconductor are explained.
MOS physics,2-3times,Energy band diagrams and carrier statistics in a metal/insulator/semiconductor (MIS) structure are discussed.

**[Class requirement]**

Semiconductor engineering, quantum mechanics (undergraduate level)

**[Method, Point of view, and Attainment levels of Evaluation]**

Final examination and a few reports

**[Textbook]**

No textbook is assigned.

**[Reference books, etc.]**

**（Reference books）**

S. M. Sze Physics of Semiconductor Devices (Wiley Interscience) \ P.Y.Yu and M. Cardona Fundamentals of Semiconductors (Springer)

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 電子材料学特論<br>Electronic Materials, Adv. | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/Second semester |
| Day/period | Thu.2 | Class style | Lecture | Language | Japanese |

**[Outline and Purpose of the Course]**

Fundamentals and recent progress in semiconductor materials and various advanced devices are explained.

**[Course Goals]**

**[Course Schedule and Contents]**

Si semiconductor,3-4times,Bulk growth, wafering, defect engineering, and impurity gettering of Si are reviewed. Silicon-On-Insulator (SOI) is also explained.
Advanced CMOS devices and materials,2-3times,Basic structures and performance enhancement of advanced CMOS devices, the core devices in LSI, are explained.
High-frequency devices and materials,2-3times,Structure and operation principle of high-frequency devices are explained. Semiconductor materials suitable for high-frequency applications are discussed.
Power devices and materials,2-3times,Structure and operation principle of power devices are explained. Semiconductor materials suitable for power conversion applications are discussed.

**[Class requirement]**

Basics of solid state physics and semiconductor engineering

**[Method, Point of view, and Attainment levels of Evaluation]**

Report evaluation, taking account of lecture attendance

**[Textbook]**

No textbook is assinged.

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.)）**

*Please visit KULASIS to find out about office hours.

| Numbering code | G-ENG11 5C816 LB72 | | |
|---|---|---|---|
| Course title <English> | 分子エレクトロニクス<br>Molecular Electronics | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,YAMADA HIROFUMI<br>Graduate School of Engineering<br>Associate Professor,KOBAYASHI KEI<br><br>Part-time Lecturer,NODA KEI<br><br>Part-time Lecturer,Part-time Lecturer |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Mon.5 | Class style | Lecture | Language | Japanese |

## [Outline and Purpose of the Course]

近年、有機ELディスプレイや有機トランジスタなど、有機分子を能動的な電子材料とする応用が進みつつある。本講義では、一般的に電気伝導性が著しく低いと考えられている有機分子のキャリア輸送性について、その微視的機構の基礎を理解するとともに、有機分子の有するさまざまな光・電気特性を学習する。また、単一／少数分子系で構成される分子素子への展開についても後述する。

## [Course Goals]

有機分子-電極界面におけるキャリア注入機構および有機分子材料内部におけるキャリア輸送機構の基礎を理解するとともに、個々の分子がもつ多様な物性と有機材料の巨視的な光・電子的性質の関係を学習することを目的とする。

## [Course Schedule and Contents]

分子エレクトロニクス研究の背景（3回）
分子エレクトロニクスは、単一分子あるいは少数分子系が示すユニークな電気特性を直接応用しようとする分子スケールエレクトロニクスと、主に有機薄膜系を対象とする有機薄膜エレクトロニクスの２つの分野から構成される。両者は異なる視点からの研究分野であるが、同時に強く相互に関連している。電子材料としての有機分子材料研究および分子エレクトロニクス研究の背景、およびその発展について講述する。

分子／有機薄膜エレクトロニクスの基礎（4回）
分子エレクトロニクス研究において用いられるさまざまな有機分子材料、有機導体、導電性高分子などの基本構造・基礎物性を理解するとともに、その電子状態・電子物性の基礎について講述する。

有機薄膜の作製と電気特性（3回）
有機薄膜の作製方法や結晶化挙動について解説する。さらに、導電性分子、半導体性分子、誘電性分子の電気特性を事例紹介し、その電子状態の概要について講述する。

有機半導体におけるキャリア伝導（3回）
電界発光（EL）ディスプレイや有機太陽電池などのデバイス開発において使用される有機半導体材料において、そのキャリア伝導機構について講述する。また、有機分子エレクトロニクスの近年の研究動向についても述べる。

分子エレクトロニクス研究の展開（1回）
今後の分子エレクトロニクスの展望について説明する。

Continue to 分子エレクトロニクス (2)↓↓↓

**分子エレクトロニクス (2)**

学習到達度の確認（1回）
学習到達度を確認する。

**[Class requirement]**

電子物性，固体物理に関する基礎知識があればよい。

**[Method, Point of view, and Attainment levels of Evaluation]**

４回程度のレポートにより評価する。

**[Textbook]**

ノート講義スタイルとする．また適宜資料を配布する．

**[Reference books, etc.]**

**（Reference books）**

Introduced during class

**[Regarding studies out of class (preparation and review)]**

配布資料ならびにノートを整理し、各自で講義内容を復習すること。

**（Others (office hour, etc.) ）**

当該年度の授業回数に応じて一部を省略することがある。 また授業順序についても適宜変更することがある。
隔年開講科目。

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | |
|---|---|---|---|
| Course title <English> | 表面電子物性工学<br>Surface Electronic Properties | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,YAMADA HIROFUMI<br>Graduate School of Engineering<br>Associate Professor,KOBAYASHI KEI |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Tue.5 | Class style | Lecture | Language | Japanese and English |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,2times,
,3times,
,4times,
,2times,
,3times,
,1time,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

（Reference books）

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.)）**

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 光物性工学<br>Optical Properties and Engineering | Affiliated department, Job title,Name | Graduate School of Engineering Professor,KAWAKAMI YOUICHI<br>Graduate School of Engineering Associate Professor,FUNATO MITSURU | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
| Day/period | Tue.4 | Class style | Lecture | Language | Japanese |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,2-3回times,
,7-8回times,
,4-5回times,
,1回times,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.)）**

*Please visit KULASIS to find out about office hours.

| Numbering code | | | |
|---|---|---|---|
| Course title <English> | 光量子デバイス工学<br>Quantum Optoelectronics Devices | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,NODA SUSUMU<br>Graduate School of Engineering<br>Associate Professor,ASANO TAKASHI |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/Second semester |
|---|---|---|---|---|---|
| Day/period | Tue.4 | Class style | Lecture | Language | Japanese |

## [Outline and Purpose of the Course]

This course first explains electron system control and optic interactions via different kinds of quantum structure. To do so, the density matrix is derived, and the optical-absorption coefficient is determined using transmission matrix elements within quantum wells, quantum dots, and density of state. Next, it is shown that control is not only possible for electron systems but also for photon systems. Finally, several examples of photonic devices are introduced and explained.

## [Course Goals]

Students will become adept at methods of calculating the light absorption coefficient and the refractive index within quantum structures. Students will also gain an understanding of the interaction of light (photons) and electrons.

## [Course Schedule and Contents]

1. Introduction (1 class)
The academic background of photonic device engineering is described.

2. Analysis methods for electron/photon interactions (7 classes)
After a review of the basics of quantum mechanics, discussion is made of two-level system and light interaction. The necessity of density matrix theory is introduced, and it is shown that this can be used to describe both a pure state and a mixed state.
Explanation is made of the differences between energy relaxation and pure phase relaxation by deriving those differences from a physics (physical) model. Further, the steady state response of the density matrix vis-#224-vis light is derived, and explanation is made of methods of using this to calculate changes in the complex dielectric constant, the absorption coefficient, and the refractive index.

3. Electron system control and electron/photon interactions (4 classes)
Explanation is made of the interactions of electrons and light within various kinds of quantum structures. Taken up first are quantum wells, with discussion of a calculation method, using integration with consideration of band structure and state density, of the complex dielectric constant. After showing the absorption spectra and polarization characteristics of intersubband transitions, explanation is made of absorption spectra and polarization characteristics in interband transitions.

4. Photon control and electron/photon interactions (2 classes)
Discussion is made of spontaneous emission control based on photon state control. Taken up as examples of photon system control methods are optical microresonators and photonic crystals, and advanced control of light/electron interactions are introduced.

5. Confirmation of extent of student learning (1 class)
Confirmation is made of the extent of student learning.

Continue to 光量子デバイス工学(2)↓↓↓

## 光量子デバイス工学(2)

### [Class requirement]

None

### [Method, Point of view, and Attainment levels of Evaluation]

Evaluations are made on the basis of reports.

### [Textbook]

The lecture notes format is used in this course.
Other reference materials may be distributed and discussed as necessary.

### [Reference books, etc.]

**（Reference books）**

Murray Sargent III, Marlan O. Scully, Willis E. Lamb, Jr. 『Laser Physics』（Westview Press）ISBN: 9780201069037

### [Regarding studies out of class (preparation and review)]

Nothing of note.

### （Others (office hour, etc.)）

*Please visit KULASIS to find out about office hours.

| Numbering code | | | |
|---|---|---|---|
| Course title <English> | 量子計測工学<br>Quantum measurement | Affiliated department, Job title,Name | Graduate School of Engineering<br>Associate Professor,SUGIYAMA KAZUHIKO |

| Target year | | Number of credits | 2 | Course offered year/period | 2019/Second semester |
|---|---|---|---|---|---|
| Day/period | Mon.4 | Class style | Lecture | Language | Japanese and English |

**[Outline and Purpose of the Course]**

As an example of high precision measurements using quantum phenomena, frequency standards, which is realized with the smallest uncertainty in all measurement quantities at present, are discussed. The principle and evaluation of frequency standards are explained.

**[Course Goals]**

The goal of this lecture is to understand that precision measurements are realized with combination of the best technologies and is based on physics.

**[Course Schedule and Contents]**

Introduction and principle of time measurement,1time,Two principles of time measurement: Reproducibility postulate and dynamic model
Fundamentals of atomic frequency standards,2.5times,Atomic states, its energy shifts, high-resolution spectroscopy and high-sensitive detection
Cesium frequency standard and atom interferometer,2.5times,Principle of Ramsey resonance and its interpretation as atom interferometer
Specification of frequency standards: evaluation methods and theoritical limit,2times,Fundamentals of evaluation of frequency stability with Allan variance, and theoretical limit of frequency stability
Noise,2times,Incoherent signals and shot noise
Relativistic theory and time,3times,Impact of special and general relativistic theory on time measurement
Others,1time,If we have time, the frequency noises of masers and lasers, and other subjects will be lectured.
Evaluation of understanding,1time,

**[Class requirement]**

Fundamentals of physics (quantum physics, in particular) and electric circuits including linear system.
The level which average graduate students of electric and electronic science and technology acquire is sufficient.

**[Method, Point of view, and Attainment levels of Evaluation]**

Report(two times, at the first lecture and the after all lectures)

**[Textbook]**

Some materials will be provided in the case we need.

**[Reference books, etc.]**

**（Reference books）**

C. Audoin and B. Guinot 『The Measurement of Time』 （Cambridge University Press） ISBN:0521003970

**Continue to 量子計測工学(2)↓↓↓**

**量子計測工学(2)**

（This is a nice book for this topic. I recommend anyone who are interested in this topic to buy one.）
Masao Kitano 『Basics of Electronics Circuit (in Japanese)』（Reimei）（This is a textbook used on the lectuer "Electronics" in fuclty. I will use this on the topic "Noise".）

**（Related URLs）**

(https://www.kogaku.kyoto-u.ac.jp/lecturenotes/(Unfortunately, this web page is discontinued from 2014. New pages would appear on PandA system.))

**[Regarding studies out of class (preparation and review)]**

In case you need.

**（Others (office hour, etc.) ）**

Office of instructor: A1-124

*Please visit KULASIS to find out about office hours.

| Numbering code | |
|---|---|

| Course title <English> | 電気伝導<br>Electrical Conduction in Condensed Matter | Affiliated department, Job title,Name | Graduate School of Engineering<br>Associate Professor,KAKEYA ITSUHIRO<br>Graduate School of Energy Science<br>Professor,DOI TOSHIYA |
|---|---|---|---|

| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Wed.2 | Class style | Lecture | Language | Japanese |

## [Outline and Purpose of the Course]

A fundamental aspect of the electrical conduction in solids is discoursed in terms of physics based on the classical dynamics and later on the quantum physics. An important concept of the phonon and the electron-phonon is discoursed, which play a very important role in the electrical conduction in solids. The electrical conductivity is discoursed with a frequency from 0, that is dc, to optical frequency, by which a unified understanding of electrical conduction and the optical property is intended.

## [Course Goals]

This class in intended to bestow the understanding of the solid state physics of a level dealt in the celebrated textbook by Ashcroft and Mermin. It is also intended for those attending in this class to acquire an ability sufficient to strive through such a textbook by himself or herself after the class is completed.

## [Course Schedule and Contents]

Lattices and reciprocal lattices (2 classes)
Explanation is made of lattices and reciprocal lattices, a fundamental item for understanding electron properties within an atom.

Fundamentals of quantum mechanics, and the hydrogen atom model (2 classes)
A simple review is made of quantum mechanics, and explication is made of electron states (energy, spatial distribution, etc.) within hydrogen and atoms other than hydrogen.

Free-electron Fermi gas (3 classes)
Explanation is made of the free-electron model as an ideal Fermi gas. Then, an overall explanation is provided of conductivity in metals, electronic specific heat, and the Hall effect.

Energy bands (2 classes)
The band structure of electron energy within a solid crystal is introduced, and explanation is provided of conductivity and the band structures of conductors, semiconductors, and insulators.

Electron-phonon interactions, and conductivity in metals and semiconductors (2 classes)
Lattice vibration is explained via quantized phonons (Bose particles) and Bose statistics, and lattice specific heat is introduced via determination of phonon density of state. Phonon scattering and electron scattering are explained. On this basis, explanation is then provided regarding the heat dependent nature of resistivity in metals, as well as of the Bloch-Gr#252neisen law at low temperature. Conductivity in semiconductors, especially scattering, is also explained.

Superconductivity (3 classes)
With respect to superconductive phenomena, explanation is made, using the London equation, of the Meissner effect, etc. Overview explanation is made of the Ginzburg-Landau theory, and order parameters are

Continue to 電気伝導(2)↓↓↓

introduced. The relationship between phase and vector potential, important for superconductivity, is explained, as well as the Josephson effect. Explained also is magnetic flux quantization within type II (high field) superconductors.

Feedback lesson (1 class)
Confirmation of learned content is made based on evaluations of short tests and the score on the final examination, etc.

## [Class requirement]

Those who would like to attend in this class are recommended to study electrodynamics, statistical physics, and introduction to the solid state devices in advance. The lecture is, however, given in Japanese.

## [Method, Point of view, and Attainment levels of Evaluation]

Basically, an examination is imposed after the last class. A report may be imposed in case of necessity.

## [Textbook]

C. Kittel 『Introduction to Solid State Physics 8th ed.』 （Wiley） ISBN:0471680575

## [Reference books, etc.]

**（Reference books）**

Solid State Physics by Ashcroft and Mermin

## [Regarding studies out of class (preparation and review)]

Preparing before classes and reviewing after classes are recommended.

## （Others (office hour, etc.) ）

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 融合光・電子科学の展望<br>Prospects of Interdisciplinary Photonics and Electronics | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,FUJITA SHIZUO | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
| Day/period | Fri.2 | Class style | Lecture | Language | Japanese and English |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

（Reference books）

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 電子工学特別研修１(インターン)<br>Advanced Seminar in Electronic Science and Engineering I | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
| Day/period | Thu.3,4,Fri.3,4 | Class style | Practical training | Language | Japanese |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,6times,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.)）**

*Please visit KULASIS to find out about office hours.

未更新

| Numbering code | | | | | |
|---|---|---|---|---|---|
| Course title <English> | 電子工学特別研修２(インターン)<br>Advanced Seminar in Electronic Science and Engineering II | Affiliated department, Job title,Name | Graduate School of Engineering<br>Professor,KIMOTO TSUNENOBU | | |
| Target year | | Number of credits | 2 | Course offered year/period | 2019/First semester |
| Day/period | Thu.3,4,Fri.3,4 | Class style | Practical training | Language | Japanese |

**[Outline and Purpose of the Course]**

**[Course Goals]**

**[Course Schedule and Contents]**

,6times,

**[Class requirement]**

None

**[Method, Point of view, and Attainment levels of Evaluation]**

**[Textbook]**

**[Reference books, etc.]**

**（Reference books）**

**[Regarding studies out of class (preparation and review)]**

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.

| Numbering code | G-INF06 53631 LJ72　G-INF06 53631 LJ11 | | |
|---|---|---|---|
| Course title <English> | 集積回路工学特論<br>Integrated Circuits Engineering, Adv. | Affiliated department, Job title,Name | Graduate School of Informatics<br>Professor,ONODERA HIDETOSHI |

| Target year | 1st year students or above | Number of credits | 2 | Course offered year/period | 2019/First semester |
|---|---|---|---|---|---|
| Day/period | Wed.4 | Class style | Lecture | Language | Japanese |
| Class type | 専攻基礎科目 | | | | |

## [Outline and Purpose of the Course]

集積回路はエレクトロニクスシステムの高機能化・高信頼性化・低価格化を担うキーデバイスである。集積回路製造技術の着実な進歩により、集積可能な回路規模は等比級数的に増大している。集積回路は1958年の誕生以来、エレクトロニクス分野に革命を起こしただけでなく、社会にも大きな影響を与えている。本講義では、このような集積回路の設計技術について、特に論理設計以降の設計工程を中心に講述する。
具体的には、集積回路設計技術の現状と技術動向、CMOSプロセス技術、CMOSレイアウト設計、MOSデバイス特性、CMOSスタティックゲート、CMOSダイナミックゲート、LSI設計法、FPGAについて講義する。本講義は、エレクトロニクスシステムの中核となる集積回路の概要とその設計技術を学修することを目的とする。

An integrated circuit is a key device that enables functionality enhancement,　performance increase, and cost reduction of an electronic system. Steady progress in fabrication technology leads to exponential increase in integration scale.　Since the birth of 1958, integrated circuits have been　revolutionalized not only electronics but also society at large.　This course focuses on the design methodology of a large-scale integrated circuit (LSI), with particular emphasis on logical and physical design process. Topics covered by the course include the current status and future directions regarding LSI design technology, CMOS process technology, CMOS layout design, CMOS device characteristics, CMOS static gates, CMOS dynamic gates, and LSI design methodology. The purpose of this lecture is to aquire basic knowledge on the overview and design technology of integrated circuits that
form the basis of future electronics systems.

## [Course Goals]

本講義の学修により、集積回路の設計フローを理解し、簡単なディジタル回路に対して論理設計、回路設計、レイアウト設計が行える程度の知識を修得することができる。

By learning this lecture, you can obtain basic knowledge on a design method of integrated circuits such that you can complete logic, circuit and layout design for a simple digital circuit.

## [Course Schedule and Contents]

以下の各項目について講述する。受講者の理解の状況を見極め、必要な場合には説明や課題を追加するなどにより、各項目あたり2-3週を充てる。

1. 集積回路設計技術の現状と技術動向: 最先端の集積回路を例にとり、集積回路の現状を説明する。集積回路の発展の経過を述べ、技術動向を検討する。
2. CMOSプロセス技術: CMOSを用いた集積回路の製造プロセスについて説明する。各製造工程で、

Continue to 集積回路工学特論(2)↓↓↓

集積回路工学特論(2)

どのようなフォトマスクが必要になるかを述べる。
3. MOSデバイス特性: 微細構造を持つMOSFETの動作特性を説明する。抵抗素子、容量素子の実現法を示す。微細化により配線性能が低下する問題と、その克服法について述べる。
4. CMOSスタティックゲート・ダイナミックゲート: 論理ゲートの回路構造として、CMOS相補型スタティックゲートとダイナミックゲートを取り上げ、動作原理や動作特性について説明する。更に、動作特性の解析法や設計法を示す。
5. LSI設計法: 大規模な集積回路の設計法として、同期式設計について説明する。同期式設計におけるタイミング設計技術やクロッキング技術を講述する。低消費電力化設計技術について説明する。
6. FPGA: ユーザーの手元でカスタム化が可能なLSIとして、FPGAが利用されるようになってきた。FPGAの原理や設計法、その応用について説明する。

Following topics will be covered. By assessing the understanding of the students and adding explanations and tasks when necessary, we will spend 2-3 weeks for each topic.

1. Current status and future directions of Integrated Circuit Technology: The current status of integrated circuit development will be explained. Brief history and future directions of integrated circuit technology will be covered.
2. CMOS Process Technology: Fabrication process of CMOS will be explained with particular emphasis on photo-masks required for lithography.
3. MOS Devices: Structure and performance characteristics of MOSFET, capacitor and resister will be explained. Performance degradation of scaled interconnect will be discussed with possible solutions.
4. CMOS Static and Dynamic Gates: CMOS complementally static gates and dynamic gates will be presented with performance analysis and design methods.
5. LSI Design Methodology: Synchronous design method will be explained. Timing analysis and clocking techniques will be discussed. Low power design methodology will be explained.
6. FPGA: Field programmable gate array and its application will be explained.

## [Class requirement]

電子回路、ディジタル回路、論理回路に関する基礎知識を有すること。

Basic knowledge on electronic circuits, digital circuits, logic circuits

## [Method, Point of view, and Attainment levels of Evaluation]

本講義の到達目標は、集積回路の設計フローを理解し、簡単なディジタル回路に対して論理設計、回路設計、レイアウト設計が行える程度の知識を修得することである。
到達目標の達成度を、授業期間中に適宜実施するレポート試験によって評価する。
レポート試験は全問を解き全回提出を必須とする。
レポート課題に対する考察内容のレベルや妥当性により評点を決める。

The target of this lecture is to obtain basic knowledge on a design method of integrated circuits such that you can complete logic, circuit and layout design for a simple digital circuit.
The level of achievement will be examined by several reports assigned during lectures. All reports discussing all problems are mandatory.
The grade will be reflected by the level and the validity of the discussions in the reports.

Continue to 集積回路工学特論(3)↓↓↓

**集積回路工学特論(3)**

**[Textbook]**

**講義資料を適宜配布する**

Hand-outs will be provided.

**[Reference books, etc.]**

**（Reference books）**

Neil H.E. Weste and David Harris 『CMOS VLSI Design, 4th Ed.』（Addison-Wesley）
Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic 『Digital Integrated Circuits, 2nd Ed.』（Prentice Hall）

**[Regarding studies out of class (preparation and review)]**

**レポート試験の中には、小規模回路の設計課題が含まれる。特性評価には回路シミュレータ**(SPICE)**が必要になる。**SPICE**の入手方法を説明するので、各自で使用環境を整えること。回路シミュレータの使い方については、概要のみ授業中に説明する。詳細な利用法は各自で自習すること。**

Reports include design and analysis of small circuits.   A simulation program (SPICE) is required for performance analysis.  Instructions for obtaining SPICE are given and students need to install SPICE by themselves. The usage of the circuit simulator is outlined only in the lecture.  Complete usage should be studied by yourself.

**（Others (office hour, etc.) ）**

*Please visit KULASIS to find out about office hours.