Lecture Outline and Schedule

Year	Module	Lecturer
Year 1 (2020) Introduction of the material classes and modeling techniques	**Introduction to lead-free perovskite ferroelectrics for electro-mechanical systems** • Mechanical Properties of Ferroelectrics **Syllabus**: This lecture is an introduction to dielectric, piezoelectric, and ferroelectric properties of ferroelectrics. In the first section, background on dielectric and piezoelectric properties will be discussed with a focus on the influence of material phenomena at multiple length scales, such as domain wall and phase boundary motion, as well as the influence of external thermal, mechanical, and electric fields. Various measurement techniques, such as Rayleigh behavior and impedance spectroscopy, will be introduced. In the second section, the large field response of ferroelectrics, namely ferroelectricity and ferroelasticity will be discussed with a particular focus on the effect of crystal structure and compositional phase boundaries, the role of domain wall motion and defects, and the influence of stress-induced structural phase transformations. Measurement techniques for characterizing large field behavior, such as the Sawyer-Tower circuit, will also be introduced. Following this lecture it is expected that the participant is familiar with the dielectric, piezoelectric, and ferroelectric properties of normal ferroelectrics and has an understanding of the crystallographic origins of the electromechanical properties. • Piezoelectric Properties of Lead-Free Ferroelectrics **Syllabus**: This course provides basic and latest information on the functional properties of ferroelectric materials, for which the orientation of spontaneous polarization changes with electric field, and also gives examples of their commercial applications. The first half of this course deals with the theories of ferroelectric materials and differences in history and characteristics between lead and lead-free based materials, then the latter half is extended to cover the topics of important ferroelectric families such as piezoelectrics which are polarized by stress, and pyroelectrics which hold spontaneous polarization without an external signal. The purpose and goal of this course is to understand the characteristics of those materials and the ways of new material design through lecture and group discussion. **Block Periods**: ~~23 – 25 Sept. at NITech, 5 - 9 Oct. at FAU~~ On-demand	Webber Kakimoto
	Materials and devices for opto-electric and energy technologies • NGSE5 Seminar **Syllabus**: - 10 Tutorials (each 1h) will be given to acquire theoretical foundations, followed by a debriefing for questions of students. - Supplementary 15 keynote speeches (each 15min) on highly topical issues will be held: 6 presentations on a timely OPV topic, 6 on a timely perovskite topic and 3 on a timely emerging PV topic. • Electronic Materials Analysis **Syllabus**: This lecture introduces theory and practice of electronic materials characterization and analysis based on the case of semiconductors. Characterization and analysis techniques for semiconductors can easily be applied to other electronic materials, and the techniques are powerful tools to know properties of the electronic materials. A textbook of the lecture will be “Semiconductor Material and Device Characterization” by Schroder, D. Wiley-IEEE Press, c2006 **Block Periods**: ~~20 - 24 July at NITech. 19 - 23 Oct. at FAU~~ On-demand	Brabec Kato
	Introduction to atomistic and mesoscale modeling • Introduction to Continuum Modeling of Electro-mechanically Coupled Problems **Syllabus**: - Tensor Calculus - Continuum Mechanics - Electro-Magneto-Dynamics - Electro-Statics - Electro-Mechano-Statics - Electro-Mechano-FEM • Simulation for Nano-Technology **Syllabus**: This lecture explains about the computer simulation methodologies at atomistic scales for analyzing and predicting various physical properties of materials. Topics will include: 1. From Electrons to Empirical Inter-atomic Potentials 2. Time-evolution Algorithms for Atomistic System 3. Calculating the Long-ranged Coulomb Interaction 4. Order-N Algorithms for the Coulomb Interaction 5. Coarse-graining of Atomistic System **Block Periods**: ~~12 - 15 Oct. at NITech, 14 - 18 Sept. at FAU~~ On-demand	Steinmann Ogata

Year 2 (2021) Processing and synthesis techniques	**Processing of functional ceramics and ceramic structures** • Additive Manufacturing of 3D Cellular Ceramic Structures **Syllabus:** - Introduction in Ceramic Processing - Additive manufacturing methods- an overview - Advantages in ceramic additive manufacturing - Characterization and simulation methods for additive manufacturing **Upload**: weekly from April • Processing of Lead-Free Polycrystalline and Single Crystal Ferroelectrics **Syllabus:** This course provides basic and latest knowledge on the synthesis of ferroelectric materials and their characterization techniques. Various properties of polycrystalline ferroelectric and the related functional materials are brought from the interdependent hierarchies of crystal structure, domain structure, grain structure and boundary/interface structure. The principal and application of instrumental analyses to characterize single- and poly-crystalline materials, thin/thick films and composites are to be explained, followed by understanding the stages of microstructure development in the materials synthesized through various processing routes. The lecture also covers the topics of environmentally benign processing technology targeted for SDGs, as well as important traditional techniques. **Block Period: On-demand (Tentative)** **Upload**: **September, 2021**	Fey Kakimoto
	Electrochemistry and growth of single crystal wide band gap semi-conductors • Growth and Characterization of Single Crystal Semi-Conductors **Syllabus:** 1. Fundamentals of Crystal Growth 2. Crystal Growth and Epitaxy of the wide bandgap semiconductors SiC, GaN/AlN, Diamond, ZnSe and Ga2O3 3. Semiconductor Wafer Characterization (optical microscopy // birefringence // defect etching // wafer mapping by photoluminescence, Raman and optical absorption) **Upload:** April • Advanced Industrial Electrochemistry **Syllabus:** Students will learn the fundamentals of electrochemistry. They will also learn the basic principles and present problems of several kinds of electrochemical energy devices such as Li ion batteries, Fuel cells, Solar cells, and others. This course also provides the students with the opportunity to discuss the challenges and potential solutions related to environmental problems. This course consists of the following content: Fundamentals of electrochemistry, Electric Double Layer Capacitors, Lithium Ion Batteries, Nano-carbon Electrodes, Fuel Cells, Solar Cells, Photo-catalysts. **Block Periods: On-demand** **Upload: August 1st, 2021**	Wellmann Kawasaki
	Synthesis and optical properties of solution processed semiconductive perovskites • Metal halide perovskite single crystal growth and applications **Syllabus:** Some fundamentals of single crystal growth from solutions Metal halide perovskite materials Why metal halide perovskites – unique properties Bulk single crystals and their applications Sheet growth of perovskite single crystals Thin film growth of perovskite single crystals Microcrystal growth of perovskite single crystals Nanocrystals of perovskite single crystals Epitaxial growth of perovskites **Upload:** weekly from April • Advanced photonic nanomaterials **Syllabus:** This course gives fundamental knowledge on electrical and optical properties of nano-sized semiconductive and ceramic materials as well as their possible applications in fields of illuminations and photovoltaics. The lecture will start with a basic of bulk semiconductors, and explain on recent artificial illuminations based on blue-LEDs. To let participants well to understand photonic properties of the nano-sized materials, a confinement of electrons and holes in nano-space will be lectured. The goal is to acquire skills to perform material designs using nanosized semiconductors and knowledge on characterizations of their electrical and optical properties. 1. Fundamentals of semiconductors 2. Bandgap estimation: Tauc analysis 3. Electron confinements: what happens for electrons and holes in nano-spaces 4. Quantum size effects 5. Applications of nano-sized semiconductors 6. Design of nanosized semiconductors and characterizations of the electrical and optical properties **Block Period: On-demand** **Upload: November 15, 2021**	Heiss Hayakawa

	Nanostructured surfaces • Modeling of Surface Phenomena **Syllabus:** TBA **Upload:** weekly from November • Ceramics Interface Chemistry **Syllabus:** Ceramics materials, which are representative of the oxide, are complexed with other oxides or metals to improve the surface/interface properties. This lecture provides the physico-chemical properties and their characterization techniques of ceramics interface at which various physical and chemical phenomena such as molecular adsorption, catalysis, electron transfer etc. take place. Students will learn the foundation and application of surface/interface chemistry occurred on advanced ceramics materials, mainly focusing on catalyst. **Block Periods: On-demand** **Upload: Late September to early October 2021.**	Meyer Haneda
Year 3 (2022) Device development and advanced characterization techniques	**Advanced structural characterization techniques** • Vibrational Spectroscopy of Amorphous To Nucleated To Fully Crystallized Materials • Synchrotron Radiation Techniques for Materials Science	Cicconi Hayashi
	Communications systems design • Electronics Design for Energy Harvesting System • Body Area Communications	Fischer Wang
	Advanced modeling techniques for mechano-electrical systems • Advanced Computational Simulation of Mechno-Electrical Systems • Advanced Lecture on Motor Drives	Mergheim Kosaka
	Bridging length scales in computational modeling • Combining Molecular Dynamics and Phase-Field Modeling • Multiphyiscs Simulation Techniques in Biomedical Engineering	Wendler Hirata