CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL

Faculty of Engineering

Information on KielMat International for Materials Science Students

2005

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C O N T E N T S

Cooperation in technology, economy, science and culture is a key issue of the European integration. Located at the Baltic Sea, Germany's northern state Schleswig-Holstein intends to play a vital role and participate in these efforts. The economical wealth of highly industrialized societies depends critically on the competitive edge of their technology, which is based on the solid education of their engineers as well as on their ability to respond quickly to the changing needs of regional and global economic conditions. Universities serve the society by performing research and providing education to their students, but the traditional ways of providing these services are rapidly changing, too. Future students must be seen as "customers", searching for the best offer in advanced education among competing universities. As a consequence, engineering disciplines are facing the needs to develop new concepts in higher engineering education in order to attract European students, and especially to prepare the students for the challenges on the job imposed on them as engineers by the fast pace of the modern technical evolution. A special challenge for engineering and natural sciences faculties in Germany is to promote public awareness of the importance of basic research and technology for a modern society and thus enhance the number of qualified students in natural and in technical science disciplines. The Faculty of Engineering of the Christian-Albrechts-University of Kiel has implemented a number of initiatives to meet these tasks.

A. GENERAL DESCRIPTION

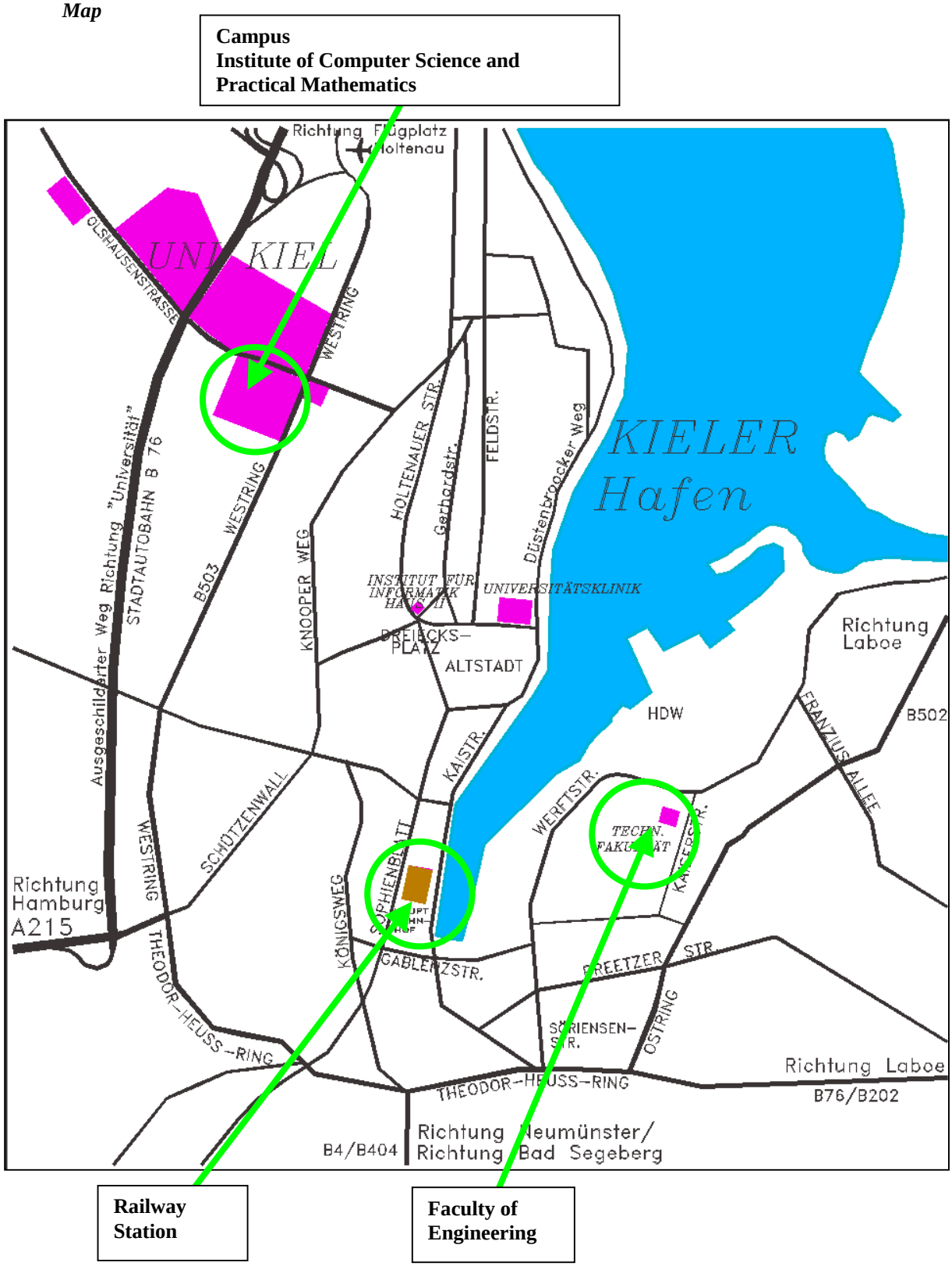
I. THE CHRISTIAN-ALBRECHTS-UNIVERSITY OF KIEL

The Christian-Albrechts-University of Kiel which was founded in 1665 by the Duke of Schleswig-Holstein consists of 9 faculties and some central institutions with now approximately 23 000 full-time students. The faculties are active in education and research in all scientific disciplines of a university: engineering, educational science, agricultural and nutritional science, mathematics and natural sciences, philosophy, medicine, economics and social sciences, law, and theology. Kiel as the capital of the state of Schleswig-Holstein is located at the fjord of Kiel, which is part of the southern coastline of the Baltic Sea just opposite the islands of Denmark. The city is also famous - among other things – for its many annual sailing events.

II. THE FACULTY OF ENGINEERING

The Faculty of Engineering as part of the Christian-Albrechts-University of Kiel understands its role as the dominant provider of modern education in engineering in the northern German state of Schleswig-Holstein. Modern engineering education programs are offered in the disciplines of electrical engineering, computer science, materials science and industrial mathematics. The Faculty of Engineering was founded in 1990 as an integral part of the Christian-Albrechts-University of Kiel. The faculty presently includes 25 research groups with about 150 scientists. The academic leaders of these research groups are responsible for all study programs offered by the faculty. At present about 650 students are educated in the different engineering disciplines.

Map


Campus
Institute of Computer Science and
Practical Mathematics
Richtung Flugplatz Holtenau
UNI KIEL
OLSHAUSENSTRASSE
WESTRING
STADTAUTOBAHN B 76
Ausgeschilderter Weg Richtung "Universität"
B503
WESTRING
KNOOPER WEG
HOLTENAUER STR.
Gerhardstr.
FELDSTR.
Düstenbrooker Weg
KIELER
Hafen
INSTITUT FÜR INFORMATIK HAUS II
UNIVERSITÄTSKLINIK
DREIECKS-PLATZ
ALTSTADT
HDW
Richtung Laboe
B502
FRANZIUS-ALLEE
KAISTR.
WERFTSTR.
TECHN. FAKULTÄT
SCHÜTZENWALL
WESTRING
Richtung Hamburg A215
KÖNIGSWEG
GABLENZSTR.
PREETZER STR.
THEODOR-HEUSS-RING
SCHRIENSEN-STR.
OSTRING
Richtung Laboe
B76/B202
B4/B404
Richtung Neumünster/
Richtung Bad Segeberg
Railway Station
Faculty of Engineering

1. Short Summary of Engineering Study Programs in Kiel

In order to meet the demands of industry and research institutions in a modern industrialized society the Faculty of Engineering has introduced several new concepts into the design of study courses. The innovations aim at modernizing and internationalizing the engineering curricula as well as the structure of the courses in order to attract more students and to promote international co-operation, especially with regard to the Baltic region. General considerations in the design of the study programs were the provision of a broad general knowledge in different fields of engineering, the response to the needs of industry and society, skills in team and project work, the need for basic science and technology, the international exchange of students and the international collaboration in engineering education. A short summary of these study course concepts will be given in the following pages.

Study Courses	**Degrees**
Electrical Engineering	Diploma of Engineering (Dipl.-Ing.) Master in Digital Communications (M. Sc.)
Computer Science	Diploma of Engineering (Dipl.-Ing.)
	Diploma of Computer Science (Dipl.-Inf.) Bachelor of Computer Science (B.Sc.) Master of Computer Science (M.Sc.)
Materials Science	Diploma of Engineering (Dipl.-Ing.) Master of Materials Science and Engineering (M.Sc.)
Engineering and Business Administration (in cooperation with the Faculty of Economics and Social Sciences)	Diploma of Engineering (Dipl.-Ing.)
Industrial Mathematics (in cooperation with the Faculty of Mathematics and Natural Sciences)	Diploma of Mathematics (Dipl.-Math.)

Study programs offered by the Faculty of Engineering of the Christian-Albrechts-University at Kiel

The new course concepts leading to different types of a diploma degree in engineering are based on the "Kiel model", a common set of course modules obligatory for all undergraduate students. In addition, an international study course program in materials science and engineering which offers study courses in English language for German and foreign students, especially also for students from the Baltic region, has been introduced in the fall of 1999. This program offers curricula, which allow obtaining the internationally compatible engineering degree of a Master of Science, and is designed to also enter a program leading to a Ph.D. degree in engineering.

2. The Research groups and their main research activities

General Materials Science (Prof. Dr. H. Föll)

Research focus:

- Electrochemistry of semiconductors–applications and theory
- Nanostructured semiconductors
- Solar cells
- Microstructuring and microfabrication
- Photonic crystals

Sensors and Solid State Ionics (Prof. Dr. W. Weppner)

Research focus:

- Ionic and electronic transport in solids
- Chemical sensors
- Electrochromic systems
- High-power batteries
- Materials for fuel cells
- Photogalvanic solar cells

Multicomponent Materials (Prof. Dr. F. Faupel)

Research focus:

- Metal-polymer interfaces
- Polymer-Metal-Nanocomposite
- Nanowire-Networks
- Diffusion and defects in solids
- Vapour phase deposition of polymers

Microstructure Research (Prof. Dr. W. Jäger)

Research focus:

- Microstructure research for functional materials, thin films and interfaces
- Electron microscopy
- Nanoanalytics in materials science and surface science

Mechanical Properties of Materials (Prof. Dr. W. Brocks – with GKSS Forschungszentrum Geesthacht)

Research focus:

- Nonlinear behavior of materials and structures
- Plasticity and viscoplasticity
- Modeling of fracture behavior
- Mechanical evaluation of structural components
- Numerical strain analyses of structures components

3. Central Facilities and Services

3.1. Department Libraries of the Faculty of Engineering

In addition to the main library of the university, two separate department libraries offer a wide selection of books and magazines covering subjects from all areas of Engineering, Materials Science and Computer Sciences. The Library for Engineering and Materials Science is a reference and a lending library. Lending periods are usually 4 weeks. Further literature on subjects of materials science and of solid-state physics can also be found in the main library of the university and in the library of the Institute of Experimental and Applied Physics. The library of the Institute of Computer Science and Practical Mathematics is a reference library. Access and support to literature search services via Internet is provided in all libraries.

Locations:

Library of Materials Science and Engineering

Building A, 1st floor, Kaiserstraße 2, 24143 Kiel (Gaarden)

Opening hours

During lecture and	Monday – Friday	9:00 – 12:00 a.m., 1:00 – 4:00 p.m.
Holiday periods	Tuesday only	1:00 - 4:00 p.m

Library of Mathematics, Computer Sciences and the Computing Center

Ludewig-Meyn-Str. 4, 24118 Kiel

Opening hours

During lecture period	Monday – Friday	10:00 a.m.– 1:00 p.m., 2:00 – 6:00 p.m.
Holiday period	Monday – Friday	10:00 a.m.– 1:00 p.m., 2:00 – 4:00 p.m.

3.2. Center for Materials Analysis (CMA)

The Materials Science and Electrical Engineering Groups of the CAU Kiel operate and maintain a pool of modern instrumentation and techniques for materials analysis, materials testing and for electron microscopy in materials science. The Center for Materials Analysis (CMA) is operated by these groups as a central facility of the Christian-Albrechts-University and offers research expertise in materials science and engineering, instruments and techniques to internal and external users and collaboration partners. Key tasks of the CMA consist in

- materials characterization - structure and properties of interfaces and thin films, spectroscopy of surfaces, mechanical testing of materials
- providing access to modern instruments and scientific expertise for materials analyses and materials testing for internal and external users
- promotion of research and service cooperation with industry and research institutes in areas of common interest
- broadening of spectrum of available techniques by resource and cost sharing through collaborations
- support of research theses
- support of student education and of engineers by teaching and lab courses on early and advanced levels in materials analysis, materials testing and electron microscopy of materials
- support job search of students by contacts to industry and research institutes

The CMA provides access to high-performance research instruments also for students in advanced analytics lab course programs and for performing experimental research theses.

3.3. Central Workshop

Successful engineering education and research work in technical engineering and materials science disciplines requires specialized experimental equipment and devices for the practical realization of new ideas. The faculty's mechanical workshop supports directly research work, lab courses for students and practical and experimental thesis work at all levels of engineering education. Operating as a service center, the staff offers technical support, instruction and know-how for the construction and fabrication of samples, tools and laboratory equipment and has at its disposal modern technical equipment, such as computer-controlled precision machines for fabrication of specialized tools and devices.

3.4. Computer Service Group

Tasks of the Computer Service group of the Faculty of Engineering consist in the support of research projects and engineering education by installing and maintaining laboratory and office computers, by consulting users, and by providing access to the local and international computer network. All computers of the faculty are networked and offer access to the Internet. The computer service group is responsible for the functioning of all workstations and personal computers and gives advice on the installation and use of new hard- and software.

3.5. The Student's Organization of the Faculty of Engineering (Fachschaft)

The student's organization of the Faculty of Engineering consists of elected students in Materials Science, Electrical Engineering and Computer Sciences. Student members of the Fachschaft are entitled to act as representatives in board meetings of the Faculty and of the University and provide information and assistance in all students‘ affairs. Close connections are maintained with the student's organization of the Institute of Mathematics. At the beginning of the winter term, a so-called “guideline service” offers guided tours through the university for beginners.

Campus office:

Ludewig-Meyn-Str. 4
Phone: +49 431 880-1497 (answering machine)
e-mail: fachschaft@math.uni-kiel.de and fachschaft@tf.uni-kiel.de

Office Kiel Gaarden:

Kaiserstr. 2, porter’s lodge
e-mail: fachschaft@tf.uni-kiel.de

4. SOCRATES/ERASMUS coordinator

The SOCRATES/ERASMUS coordinator of the Faculty of Engineering will assist you in preparing and organizing your stay and your studies in Kiel. Please feel free to contact the coordinator to find answers to all further questions.

SOCRATES/ERASMUS coordinator:

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B. INTERNATIONAL STUDY COURSE PROGRAM IN MATERIALS SCIENCE AND ENGINEERING

I. THE PROGRAM

The study course programs offered in materials science provide the students with the necessary knowledge, the practical skills and the first experimental and research experience in order to be able to obtain recognized degrees of different academic qualification: Diploma of Engineering, and Master of Material Science and Engineering (M.Sc.).

An international study course program in materials science and engineering, which offers study courses in English language for German, and students from abroad has been introduced in autumn 1999.
With this new study course the Faculty of Engineering aims at modernizing and internationalizing its engineering education in order to attract more students and to promote international cooperation, especially also with regard to the Baltic region. General considerations in the design of the study programs were the provision of a broad general knowledge in different fields of engineering, the response to industry and society, skills in team and project work, the need for basic science and technology, the international exchange of students and the international collaboration in engineering education.

The course program in materials science is based on modern educational units, which comprise theoretical and lab training provided by highly qualified and internationally renowned researchers. Important common elements of the study course programs in the engineering education in Kiel include excellent scientific equipment for lab course modules, collaborations with research institutions, such as the GKSS Research Center in Geesthacht and the Fraunhofer Institute for Silicon Technology in Itzehoe, collaborations with industry, internet learning modules, obligatory courses aiming at improving non-technical skills important for engineers, such as in legal matters, social sciences, and business administration, laboratories with multi-media equipment, and group rooms for students. International acceptance of course work as basis for the mobility of students within the European region is achieved through a credit point systems part of which is the European credit point transfer system (ECTS), which guarantees the mutual acceptance of course modules within the European region. Personal contact to the students, especially important also for foreign students, which are not yet familiar with the German way of living, is assured through a mentor system.

II. METHODS OF TEACHING AND LEARNING

Course lectures

The contents of courses are usually taught as a lecture. In general, a lecture lasts 90 minutes, corresponding to 2 SWS (2 hours per week). Unless explicitly announced, the enrollment for participation is not needed.

Exercises

Exercises are offered in addition to the lectures in order to further the students‘ understanding of the subject. Problem solving exercises enable the students to check and extend their knowledge and familiarize them with the course content.

Practical laboratory course training

The laboratory course programs consist of short work projects for the students and intend to provide students with practical skills and hands-on experience with scientific instruments as well as first contacts with technical

and scientific problems. Performance certificates are issued for the successful completion of a sufficient number of tests or a final colloquium rated (at least) with grade ‚sufficient'

Seminars

Seminars serve to extend and deepen the knowledge in various special areas of materials science, to practice the skills in presenting results in the form of a scientific lecture, and to discuss particular technical subjects. Each participating student prepares a subject and presents the subject in a lecture in front of the student partners. The subjects of the seminars cover current topics in materials research.

Master Thesis

The graduate thesis as the final part of the study program is usually performed after the written and oral examinations. For the duration of 3 months, the students work on a specific research subject as members of one of the research groups of the Faculty of Engineering. The results of the thesis work are documented in a scientific paper and given as an oral presentation in an internal colloquium.

III. ECTS GRADES

All certificates of academic performance and written examinations are assessed according to the German grading system. The table below shows the conversion of German grades into internationally used ECTS grades:

	German grade	***ECTS grade***	***Students achieving this grade in %***
Very Good	1,0	A	10 %
	1,3	A-	
Good	1,7	B+	
	2,0	B	25 %
	2,3	B-	
Satisfactory	2,7	C+	
	3,0	C	30 %
	3,3	C-	
Passed	3,7	D	25 %
	4,0	E	
Failed	4,3	FX	
	4,7	F	10 %
	5,0	F	

Conversion of German grades into ECTS grades

IV. SURVEY OF THE MASTERS COURSE IN MATERIALS SCIENCE

It is characteristic of this technical engineering education that examinations have to be passed in individual or in combined subject areas. The examinations and tests are taken at the end of the lecture courses. All required subjects are offered once a year, i.e. every second term. Besides the required subjects, students are offered technical and non-technical elective subjects. The attendance at these courses is proven through tests or

performance certificates. In order to promote the studies, regulations allow an additional ‚free attempt' in taking a particular examination, provided that certain deadlines for registration have been observed.

The Masters Program is a 2-years study course program and allows to obtain the internationally compatible degree of a Master of Science (M.Sc.) of Materials Science and Engineering. The program provides thorough training in all fundamental and applied aspects of functional materials including semiconductors and semiconductor technology (in cooperation with the Institute for Silicon Technology in Ithehoe) as well as in specific topics of structural materials (in cooperation with the GKSS Research Center in Geesthacht).

Admission requires a bachelor in materials science or an equivalent B.Sc. degree.

Study courses are given exclusively in English.

Basics and essentials from Mathematics, Physics, Chemistry	**Science of Materials**	**Theory of Materials**	**Applications and Technology**	**Economics, Languages, Social Skills**
Required (45.5 ECTS)				
Mathematics for Materials Scientists (4)	Materials Analysis I+II (8) Engineering Mechanics (4)	Thermodynamics and Kinetics I+II (8) Solid State Physics for Engineers I+II (8)	Basic Laboratory Course (5.5) Scientific Methods (5.5)	Tutorial (0) Economics II (2.5)
4 ECTS	12 ECTS	16 ECTS	11 ECTS	2.5 ECTS
Optional (59.5 ECTS)				
Crystallography (2.5)	Ceramic Materials (4) Development of Materials (2.5) Defects (4) Electrochemical And Chemical Aspects of Materials (4) Electronic Materials (4) Electron Microscopy I+II (8) Finite Elements Modeling (4) Electrochemical Impedance Spectroscopy (2.5) Introduction to Electrochemistry (2.5) Ionics (4) Metals I+II (8) Polymers I+II (8) Semiconductors I (4) Sensors (4) Silicon Technology I+II (5) Thin Solid Films I+II (8) Surface Analysis Methods (2.5)	Quantum mechanical Aspects in Materials Science (4) Statistical Methods in Materials Science (4)	Laboratory Course: Functional Materials (5.5) Electronic measurement techniques (4) Laboratory Technique and Materials Preparation (4) Solid State Synthesis Methods (4) P-TEM (4)	German Language Classes (2.5-7.5) Economics I (2.5)
	24 ECTS		5.5 ECTS	17.5 ECTS
Master Thesis (15 ECTS)				
120 ECTS = 4 Semesters				

Survey of the contents of the Master study course program

C. LIST OF COURSES

course: ***Basic Laboratory Course for Master Students: Materials Testing***

type: Laboratory course *lecturer:* Dolgner
semester: WS
hours per week: 4 *ECTS credits:* 5,5
content: M301 Structure and Properties
M302 Phase Transformation
M303 Stress and Strain
M304 Processes of Precipitation / Diffusion
M405 Electrical Resistance
M406 Magnetism
M408 X-ray Diffraction
M501 Deformation and Recrystallisation
M506 Melting and Solidification
M508 Spectroscopy

literature:
recommended: Master 1st semester
examination: Oral

course: ***Ceramic Materials***

type: lecture + exercises *lecturer:* Weppner
Semester: WS
hours per week: 3 *ECTS credits:* 4
content:
1. Fundamentals: ceramic processes and products, structures of crystalline ceramic materials, structures of glasses, defects, surfaces, interfaces and grain boundaries
2. Preparation of Ceramic Materials
3. Mechanical and Thermal Properties
4. Ceramic Conductors: heating elements, Ohmic resistors, varistors, ceramic superconductors
5. Dielectrics and Insulators
6. Piezoelectric Ceramics
7. Pyroelectric Ceramics
8. Electrooptic Ceramics
9. Magnetic Ceramics
10. Ionic Ceramics: fuel cells, batteries, electrochromics, supercaps, photogalvanic solar cells, water

Literature:

1. Kingery, W.D., Bowen, H.K., Uhlmann, D.R.: Introduction to Ceramics, Wiley-Interscience, New York
2. Moulson, A.J., Herbert, J. M.: Electroceramics (Materials, Properties, Applications); Chapman & Hall, London
3. Steele, B.C. H. (Hrsg.): Electronic Ceramics; Elsevier Applied Science, London
4. Hench, L.L., West, J.K.: Principles of Electronic Ceramics; Wiley-Interscience, New York

Recommended: Master 3rd semester
Examination: oral

course: ***Crystallography for Materials Scientists***

type: Lecture + exercises *lecturer:* Depmeier
Semester: WS
hours per week: 2 *ECTS credits:* 2,5
content:
- Morphology, stereographic projection. Lattices, reciprocal lattice, Miller-indices.
- Symmetry operations, point groups, space groups.
- Diffraction, Ewald construction. Experimental techniques. Structure determination.
- Crystal physics, tensors, anisotropy of physical properties.
- Crystal growth

Literature:
1. F. D. Bloss : Crystallography and Crystal Chemistry. Holt, Rinehart & Winston, Inc., NY, 1971.
2. J. F. Nye : Physical Properties of Crystals. Oxford Clarendon Press, 1985.

Recommended: Master 1st semester
Examination: oral

course: ***Development of Materials with Functional Properties for Energy and Environmental Technologies***

type: lecture + lab course *lecturer:* Thangadurai
Semester: WS
hours per week: 4 (fortnightly) *ECTS credits:* 2,5
content: The course gives an intensive description of various synthesis methods of functional solid state material, which includes ionic and mixed conductors. Emphasis is given to design functional materials based on composition-structure-property correlations.
Tentative Contents:
1. Classification of Solids
2. Diffusion: Aspects of Solid-Solid Reactions
3. Solid State Synthetic techniques
Conventional Ceramic Method Low-temperature Precursor Routes, Solvation, Transport and Rapid Reaction Routes Chemie Douce (intercalation and ion-exchange) Molten salt fluxes and hydrothermal synthesis High Pressure Methods and Solid state metathesis reactions
4. Solid state characterization methods: Powder XRD, Electron diffraction, TGA and DTA analysis, DC and AC conductivity measurements, Galvanic cell measurements, transport number determination and spectroscopic methods.

Literature:
1. West, A. R.: Solid State Chemistry and its Applications, John Wiley & Sons. New York.
2. Rao, C. N. R. and Gopalakrishnan, J.; New Directions in Solid State Chemistry, Cambridge University Press, London.
3. Rouxel, J. and Tournoux, M.: Chimie Douce with Solid Precursors, Past

and Present" Solid State Ionics 84, 141-149 (1996).

4. Roy, R.: Accelerating the kinetics of low-temperature inorganic syntheses, J. Solid State Chem. 111, 11-17 (1994).
5. Manthiram, A.: Low temperature synthesis of insertion oxides for lithium batteries, Chem. Mater. 10, 2895-2909 (1998).

Recommended: Master 3rd semester
Examination: oral

course: ***Defects in Crystals***

type: lecture + exercises *lecturer:* Föll
Semester: SS
hours per week: 3 *ECTS credits:* 4
content: 1. Point defects: types, concentration, their role in diffusion, point-defect generation and reactions, detection methods
2. Dislocations: structures and reactions, geometrical and elastic properties, experimental observations
3. Interfaces: grain boundaries, coincidence lattice concept, phase boundaries, misfit dislocations

Literature:
1. Hyperscript "Defects" http://www.tf.uni-kiel.de/matwis/amat/
2. Hull, D., Bacon, D.J.: to Dislocations; Pergamon Press
3. Hirth, J.P., Lothe, J.: Theory of Dislocations, McGraw Hill

Recommended: Master 2nd semester
Examination: oral

course: ***Economics I***

type: lecture *lecturer:* Foders
semester: SS
hours per week: 2 *ECTS credits:* 2,5
content: Economics and International Management gives an introduction to the field of economics and management for engineers. The topics addressed include supply, demand and product markets, pricing, business organization, production and costs, the labor market, managerial finance and the impact of globalization on business and the world economy. The intention of the course is to present the essential core of economics and management in a way that enables students to understand the basic facts of economic life. Case studies are used to help students apply the principles of economics to real world situations.
literature:
recommended: Master 2nd semester
examination: written

course: ***Economics II***

type: lecture *lecturer:* Foders
semester: WS

hours per week: 2 *ECTS credits:* 2,5

content: This course deals with economic growth and international economics. It first gives an overview of the theory of economic growth and its links with other fields (demography, education). Then it introduces the student to the theory of international trade, finance and migration. The topics are presented and discussed using case studies and current international statistics.

literature:
1. De Long, J. Bradford (2002), Macroeconomics. New York: McGraw-Hill;
2. Krugman, Paul K., Maurice Obstfeld (1994), International Economics: Theory and Policy, New York: Harper Collins College Publishers;
3. Dornbusch, Rüdiger, Stanley Fischer (1994), Macroeconomics, New York: McGraw-Hill.

recommended: Master 1st semester

examination: written

course: ***Electrochemical And Chemical Aspects of Materials – An Experimental Approach***

type: lecture + exercises *lecturer:* Wing Fong Chu

semester: WS

hours per week: 3 *ECTS credits:* 4

content: 1. Some general aspects General features of bond formation, important definitions and laws,
2. Thermochemistry,
3. Homogeneous chemical equilibria,
4. Heterogeneous equilibria and chemical kinetics,
5. Equilibria involving ions,
6. Ions in solution,
7. Electromotive force,
8. Chemical energy and electrical energy: electrochemistry,
9. The corrosion system: Material / corroding media,
10.Principles of corrosion,
11.Investigation of the corrosion resistance and corrosion protection

literature: P.W. Atkins, The Elements of Physical Chemistry
J.C. Anderson, K.D. Leaver, R.D. Rawlings and J.M. Alexander, Materials Science
Walter J. Moore, Physikalische Chemie
Gustav Kortüm, Lehrbuch der Elektrochemie
Gerd Wedler, Lehrbuch der Physikalischen Chemie

recommended: Master 1st semester

examination: written

course: ***Electrochemical Impedance Spectroscopy***

type: lecture *lecturer:* Georgi Popkirov

semester: SS

hours per week: 2 *ECTS credits:* 2,5

content: Historical background
A.C. circuits, Impedance-related functions

Impedance measurement techniques; frequency and time domain methods
Data validation, nonstationarity, nonlinearity, noise etc.
Other impedance techniques
Bulk and interface properties, metal and semiconductor electrodes
Impedance and Electrochemistry (solid state & aqueous)
Analysis of impedance spectra, Equivalent circuits, Distributed circuit elements
Identification of electrochemical cell parameters
Applications of impedance spectroscopy
The EIS- 6416 FFT-Impedance spectrometer - introduction, discussion and practical work

Exercises: Practical exercises in small groups of interested students

literature:
recommended: Master 2nd semester
examination:

course: ***Electronic Materials***

type: lecture and exercises *lecturer:* Föll
semester: WS
hours per week: 3 *ECTS credits:* 4
content:
1. Introduction: meeting conflicting requirements with this course, scope of the course, format of exercises.
2. Thermical Properties:
3. Conductors: metallic and non-metallic conductors, classification, requirements, properties, special conductors and special applications
4. Dielectrics: general reactions, mechanisms of polarization, frequency dependence, complex dielectric constant and dielectric function, piezoelectric- and ferroelectric materials, optical properties
5. Materials and Processes of Si-Technology: process integration and mass production requirements, MOS, CMOS and bipolar technologies, Si production and epitaxy, CVD methods, etching, oxidation and metalization
6. Magnetism and Magnetic Properties: definitions and classifications, dia- para- and ferromagnetism, mean field theory of ferromagnetism, definitions, magnetic domains, hard and soft magnets, applications

literature:
1. Hyperscript in the Internet http://www.tf.uni-kiel.de/matwis/amat/elmat_en/index.html
2. L.A.A. Warnes: Electronic Materials
3. R.E. Hummel: Electronic Properties of Materials
4. G.F. Fasching: Werkstoffe für die Elektrotechnik
5. W. v. Münch: Werkstoffe der Elektrotechnik

recommended: Master 1st semester
examination: written

course: ***Electron Microscopy I***

type: lecture + exercises *lecturer:* Spiecker
semester: WS
hours per week: 3 *ECTS credits:* 4

content: The course gives an introduction to the fundamentals and methods of microscopy and spectroscopy with electrons and related techniques and their applications to the physics, chemistry and biology of solids and interfaces and to materials science.
Subjects encompass:

- Scanning tunneling microscopy and spectroscopy
- Related scanning probe microscopies, in particular atomic force microscopy
- High-resolution transmission electron microscopy
- Spectroscopic methods of analytical tranmission electron microscopy

literature:

1. B. J. Fultz, J. M. Howe: Transmission Electron Microscopy and Diffractometry of Materials. Springer-Verlag 2001.
2. L. Reimer: Transmission Electron Microscopy - Physics of Image Formation and Microanalysis. Springer-Verlag 1997.
3. D. B. Williams, C. B. Carter: Transmission Electron Microscopy - A Textbook for Materials Science. Plenum Press, New York 1996.
4. H. Alexander: Physikalische Grundlagen der Elektronenmikroskopie. Teubner Studienbücher, Teubner-Verlag Stuttgart 1997.
5. J. A. Stroscio and W. J. Kaiser (Eds.): Scanning Tunneling Microscopy. Academic Press, San Diego 1993.
6. R. Wiesendanger: Scanning Probe Microscopy and Spectroscopy. Cambridge University Press, Cambridge 1994

recommended: Master 3rd semester
examination: oral

course: ***Electron Microscopy II***

type: lecture + exercises *lecturer:* Spiecker
semester: SS
hours per week: 3 *ECTS credits:* 4
content: The course gives an introduction to the methods of analytical transmission electron microscopy and their applications in materials science:
X-ray microanalysis
Electron energy loss spectroscopy and energy filtering transmission electron microscopy
Scanning transmission electron microscopy
Convergent beam electron diffraction

literature:

1. Principles of Analytical Electron Microscopy, Eds. D. C. Joy, A. D. Romig,Jr., J. I. Goldstein, Plenum Press New York 1996
2. L. Reimer: Transmission Electron Microscopy - Physics of Image Formation and Microanalysis. Springer-Verlag 1997
3. D. B. Williams, C. B. Carter: Transmission Electron Microscopy - A Textbook for Materials Science, Plenum Press, New York 1996
4. Materials Science and Technology (Eds. R.W.Cahn, P.Haasen, E.J.Kramer) Vol. 2 Characterization of Materials VCH 1992

recommended: Master 4th semester
examination: oral

course: ***Engineering Mechanics***

type: Lecture + exercises *lecturer:* Steglich

semester: SS

hours per week: 3 *ECTS credits:* 4

content: The objective of this course is to emphasize the formulation of problems in mechanics, to reduce complex problems into appropriate mechanical and mathematical models, and to cultivate a habit of questioning, analyzing, designing, and inventing in engineering and science.
At the beginning, continua are defined with regard to real materials and the concept of continua is explained. The basic governing equations are derived. In the following the course is organized as follows: After a review of the terms motion and displacement the treatment of stresses and strain is trained. The practical techniques of determining the principal stress and strains, and the concept of compatibility, are given special emphasis. Finally, the linearized theory of elasticity, theories of bending and torsion are described and are used to solve practical problems in engineering science. Some exercises that train in applying some of the formulas derived are performed. If the student obtains a clear idea about the stress, strain, and constitutive equations, and knows how to use them in formulating scientific and engineering problems, the main goal of the course is achieved.

literature:

recommended: Master 2nd semester

examination: oral

course: ***Finite Elements Modelling***

type: lecture + exercises *lecturer:* Steglich

semester: WS

hours per week: 3 *ECTS credits:* 4

content: Repetition of fundamentals of strength of materials and introduction into continuum mechanics of solids: stress and strain tensors, balance equations, constitutive equations of linear elasticity,
formulation as boundary value problem and variational problem (principle of virtual work) introduction into the finite element method (FEM): discretization of the continuum, shape and displacement functions, isoparametric elements, (elastic) constitutive equations, local and global stiffness matrices and load vectors, solution of equations, general structure of a FE programme: input data, flow diagram of problem solution, results,
application of the FE programme ANSYS with computer exercises: meshes and other input data, FE simulations, presentation, evaluation and interpre-tation of results, individual working on case and parameter studies: bending of a rectangular panel, panel with hole under biaxial tension, smooth and notched tensile bars, cylindrical pressure vessel etc.

literature:

1. W.M. Lai, D. Rubin, and E. Krempl: to continuum mechanics, Pergamon Press, 1993.
2. Gurtin, M.E.: "An to continuum mechanics", Academic Press, 1981.
3. K.J. Bathe, Finite Element Procedures, Prentice Hall, New Jersey 07632, 1996.

recommended: Aimed at students in materials science (Diplom or Master) or other engineering sciences, PhD students.
Requirements: BSc or intermediate diploma examination, basic knowledge of strength of materials as presented in "Engineering Mechanics"

examination: oral + practical

course: ***Introduction to Electrochemistry***

type: lecture + exercises *lecturer:* Popkirov
semester: SS
hours per week: 2 *ECTS credits:* 2,5
content: Introduction: historical background, electrochemistry as science, applications, materials science aspects
Electrochemical cells: electrodes, electrolytes, ions and solutions
Ion-solvent and ion-ion interactions, conduction of electrolytes, Interfacial region of metal-electrolyte and semiconductor-electrolyte junctions
Thermodynamic properties and electrode potentials
Fundamentals of electrode reactions and kinetics, Mass transport to electrodes
Electrochemical and photoelectrochemical properties of semiconductors
Measurement methods and instrumentation for electrochemical studies
Applications: batteries, fuel cells, electrolysis, electrodeposition, metal finishing and processing, semiconductor micromachining, sensorsm corrosion prevention Exercises: Instead of weekly exercise classes, small groups will work on a specific topic, write a report and present it to the class.

literature:
1. Literature D. Pletcher, A First Course in Electrode Processes, The Electrochemical Consultancy, 1991.
2. C.M.A.Brett, A.M.O.Brett, Electrochemistry - Principles, Methods and Applications, Oxford University Press, 1993.

recommended: Master 2nd semester
examination:

course: ***Ionics***

type: lecture + exercises *lecturer:* Weppner
semester: WS
hours per week: 3 *ECTS credits:* 4
content:
1. Disorder: disorder equilibria, disorder reactions, heterogeneous equilibria, Brouwer diagrams
2. Transport Processes In Solids: phenomenological description, statistical description, diffusivity, tracer diffusion, chemical diffusion, conductivity, heterogeneous catalysis, minority charge carriers
3. Materials and Determination of Transport Properties: super ion conductors, minority and majority charge carriers
4. Galvanic Cells for the Determination of Thermodynamic and Kinetic Data: Nernst`s and Helmholtz`s treatment, determination of Gibbs energies and phase equilibria, determination of kinetic data.
5. Galvanic Cells for Practical Applications: chemotronic elements, sensors,

electrochromics, fuel cells, high performance batteries

literature: Rickert, H.: Electrochemistry of Solids, Springer-Verlag, Berlin
Hayes, W., Stoneham, A.M.: Defects and Defect Processes in Nonmetallic Solids, Wiley-Interscience, New York
Deportes, C.: Electrochimie des Solides, Presses Universitaires de Grenoble, Grenoble
Kudo, T. Tueki, K.: Solid State Ionics, VCH, Weinheim

recommended: Master 1st or 3rd semester

examination: oral

course: ***Laboratory Course: Functional Materials***

type: laboratory course *lecturer:* Dolgner, Faupel, Föll, Jäger, Weppner

semester: SS

hours per week: 4 *ECTS credits:* 5,5

content: FM1 Shape Memory
FM2 Sorption and Diffusion in Membranes
FM3 Contact Angle
FM4 EMF Measurements
FM5 Piezo and Pyroelectric Materials
FM6 Memory Elements
FM7 Porous silicon
FM8 IV-Curve of Solar Cells
FM9 TEM of dislocations in heterostructures

literature:

recommended: Master 2nd semester, Basic Laboratory Course

examination: lab reports

course: ***Laboratory Course: Scientific Methods***

type: laboratory course *lecturer:* Dolgner, Faupel, Föll, Jäger, Weppner

semester: WS

hours per week: 4 *ECTS credits:* 5,5

content: SM01 IS
SM02 CELLO
SM03 CO2 and O2 Sensors
SM04 Lithium Battery
SM05 XPS
SM06 AFM
SM07 DMA
SM08 TEM
SM09 SEM
SM10 DTA

literature:

recommended: Master 3rd semester, Laboratory Course: Functional Materials

examination: lab reports

course: ***Laboratory Technique and Materials Preparation***

type: Lecture + exercises *lecturer:* Wing Fong Chu
semester: SS
hours per week: 3 *ECTS credits:* 4
content: The course gives an introduction to useful laboratory techniques, such as purification of materials and gases, production of medium- and high-temperature furnaces, uniaxial and isostatic pressing, ball milling, attritor milling, polishing, screen-priting, tape casting, etc. Important materials preparation methods, such as solid state reaction, glycin-nitrate-process, sol-gel process will be presented. The lecture is accompanied by practical training in the laboratory.
literature:
recommended: Master 2nd semester
examination:

course: ***Materials Analysis I+II***

type: lecture + exercises *lecturer:* Jäger
semester: WS+SS
hours per week: 3 each semester *ECTS credits:* 4 each emester
content: Overview - particle beam and radiation methods
X-ray diffraction methods
Scanning electron microscopy
Transmission electron microscopy
literature:
1. J. M. Walls (Ed.): Methods of Surface Analysis; Cambridge University Press 1989
2. E. Fuchs, H. Oppolzer, H. Rehme: Particle Beam Microanalysis - Fundamentals, Methods and Applications; VCH 1990
3. C. R. Brundle, C. A. Evans Jr., S. Wilson (Eds.): Encyclopedia of Materials Characterization; Butterworth-Heinemann 1992
4. Materials Science and Technology (Eds. R.W.Cahn, P.Haasen, E.J.Kramer): Vol. 2 Characterization of Materials VCH 1992

recommended: Master 1st and 2nd semester
examination: Oral

course: ***Mathematics for Materials Scientists***

type: lecture + exercises *lecturer:* Stolwijk
semester: WS
hours per week: 3 *ECTS credits:* 4
content: (A)
+ Recapitulation of Basic Requirements
+ Notation, Textbooks, Formularies, Calculators + PC Programs
(B) ALGEBRA

+ Complex Numbers
+ Vectors + Matrices in N-Dimensions
+ Linear Systems of Equations
+ Eigenvalues and Eigenvectors
+ Scalar Product + Vector Product
(C) CALCULUS I: FUNCTIONS DEPENDING ON ONE VARIABLE
+ Recapitulation: Derivatives + Integrals
+ Sequences + Series
+ Taylor Series + Fourier Series
+ Important Non-Elementary Functions (Error Function etc.)
(D) CALCULUS II: N-DIMENSIONAL SPACE
+ Functions Depending on More Than One Variable
+ Partial Derivatives, Derivatives in Certain Directions
+ Total Derivatives
+ Minimization Problems in N-Dimensions
+ Simple N-Dimensional Integrals
(E) NUMERICAL METHODS
+ Searching for Zeros and Extreme Values of Functions
+ Newtons Algorithm
+ Gradient Methods for Minimization
+ Numerical Integration

literature: All text book of advanced math are useable, but there is no real need of a book.
recommended: Master 1st
examination: Written

course: ***Metals I***

type: lecture + exercises *lecturer:* Rätzke
semester: WS
hours per week: 3 *ECTS credits:* 4
content:

1. Introduction

2. Alloys
2.1 Thermodynamic considerations
2.2 Examples of phase diagrams
2.3 Intermetallic phases

3. Mechanical Properties
3.1 Plastic deformation in single crystals via dislocations
3.2 Deformation twinning
3.3 Deformation of polycrystals
3.4 Creep
3.5 Fracture
3.6 Solid solution hardening

4. Thermally Activated Processes
4.1 Diffusion
4.2 Recrystallization

5. Solidification of Metallic Melts
6. Transformation in the Solid State
7. Particle Hardened Alloys
Summary

literature: P. Haasen, Physical Metallurgy, Cambridge University Press, Cambridge 1996 (German edition available)
K. Easterling, Modern Physical Metallurgy, Butterworths 1983
A. Cottrell, An Introduction to Metallurgy, The Institute of Metals 1995 (reprint at 1975 edition)
N. Stoloff, Physical Metallurgy and Processing, Chapman 1994
R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, PWS-Kent 1992
R.E. Smallman and R.J. Bishop, Modern Physical Metallurgy of Materials Engineering, Butterworth/Heinemann/1999
R. Cahn und P. Haasen (Eds.), Physical Metallurgy, Elsevier Science 1996

recommended: Master 1st semester

examination: written

course: ***Metals II***

type: Lectures and exercises *lecturer:* Faupel

semester: SS

hours per week: 3 *ECTS credits:* 4

content:
1. Ferrous alloys
   Steels
   Cast irons
2. Nonferrous alloys
3. Metallic glasses and quasicrystals
4. Nanocrystalline alloys
5. Thin films
   Microstructure
   Mechanical properties
   Electomigration
6. Electronic properties
7. Magnetic properties and materials
8. Superconductivity in alloys
9. Corrosion
   Wet chemical corrosion
   High temperature oxidation
10. Friction, abrasion and wear
11. Metals technology
    Forming
    Sintering and powder metallurgy
    Welding, brazing and soldering
12. Composites

literature: R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, PWS-Kent 1992
P. Haasen, Physical Metallurgy, Cambridge University Press, Cambridge 1996 (German edition available)
A.Cottrell, An introduction to Metallurgy, The institute of Metals 1995 (reprint at 1975 edition)
R.E. Smallman and R.J. Bishop, Modern Physical Metallurgy of Materials Engineering, Butterworth/Heinemann 1999
K. Easterling, Modern Physical Metallurgy, Butterworths 1983
N. Stoloff, Physical Metallurgy and Processing, Chapman 1994
R. Cahn und P. Haasen (Eds.), Physical Metallurgy, Elsevier Science 1996

recommended: Master 2nd semester
examination:

course: ***Polymers I***

type: lecture + exercises *lecturer:* Faupel
semester: SS
hours per week: 3 *ECTS credits:* 4
content: Lecture notes
1. Overview: Properties and Classification of Plastics
2. Binding Forces and Structure
3. Polymer Synthesis
4. Polymers in Melts and Solutions Thermodynamics and chain kinetics
5. Crystallization and Glass Formation
6. Mechanical Properties
7. Sorption, Diffusion and Permeation

literature:
1. U. Eisele: Introduction to Polymer Physics (Springer 1990)
2. L.H.Sperling: Introduction to Physical Polymer Science (John Wiley 1992)
3. R.J. Young, P.A. Lovell: Introduction to Polymers (Chapman & Hall 1991)
4. N.G. McCrum, C.P. Buckley, C.B. Bucknall, Principles of Polymer Engineering, Oxford Science Publications 1995.

recommended: Master 2nd semester
examination: written

course: ***Polymers II***

type: lecture+seminar *lecturer:* Scharnberg
semester: WS
hours per week: 3 *ECTS credits:* 4
content: Lecture notes

1. Plastics Processing
2. Reinforced Polymers
3. Liquid Crystalline Polymers
4. Dielectric and Optical Properties
5. Conducting and Semiconducting Polymers
6. Polymers in Microelectronics
7. Polymer Electrolytics
8. Organic Thin Films
9. Polymer Surfaces
10. Adhesives
11. Shape-Memory Polymers
12. Electroactive Polymers

literature:
recommended: for Students of Master's program in Materials Science and of Diploma program in Materials Science, Physics, Chemistry, Earth Science, and Electrical Engineering

examination: written

course: ***Practical Transmission Electron Microscopy (P-TEM)***

type: lecture + exercises *lecturer:* Spiecker

semester: WS

hours per week: 3 *ECTS credits:* 4

content: The lectures give, in combination with the exercises, an introduction into the practical work with a transmission electron microscope (TEM). The following topics are covered: Sample preparation techniques, components of a TEM, interaction of fast electrons with material, interpretation of TEM images and diffraction patterns. In the exercises the participants perform own experimental work, both, in the sample preparation lab and at the transmission electron microscope, and present their results to the group.

recommended: B. Sc.

literature: P.J. Goodhew, J. Humphreys, R. Beanland: Electron Microscopy and Analysis; Taylor & Francis 2001 (3nd edition)
E. Fuchs, H. Oppolzer, H. Rehme: Particle Beam Microanalysis - Fundamentals, Methods and Applications; VCH 1990
D.B. Williams and C.B. Carter: Transmission Electron Microscopy – A Textbook for Materials Science; Plenum Press 1996

examination: oral

course: ***Quantum Mechanical Aspects in Materials Science***

type: lecture + exercises *lecturer:* Carstensen

semester: WS

hours per week: 3 *ECTS credits:* 4

content: Discussing problems of solid state physics the general aspects of quantum mechanics will be introduced. The quantummechanical way of thinking will be teached instead of focussing on the mathematical calculations of several physical problems. The mathematical concept of quantummechanics will be introduced by applying it on several examples of solid state physics. Quantummechanic terms like linear hermetic operators, Schrödingers equation, Heisenbergs uncertainty principle, fermions, bosons, tunneling effect and electrons in solid materials shall be combined with personal practical experiences.

literature:
1. Cl. Cohen-Tannoudji, Bernard DIu, Frank Laloe, Quantum Mechanics (Volume I), John Wiley & Sons, Paris, 1977
2. Ashcroft/Mermin, Solid State Physics, Saunders College Publishing

recommended: Master 3rd semester

examination: oral

course: ***Semiconductors I***

type: lecture + exercises *lecturer:* Föll

semester: WS

hours per week: 3 *ECTS credits:* 4

content:
1. Introduction: relation to other courses, required background knowledge, timetable, exercises, homework and seminar; suggested topics for seminar; goals and content
2. Basic Semiconductor Physics: basic band theory; selected elements of advanced theory
3. Silicon: general properties and material technologies; general properties,

diffusion, crystal growth and wafer production, device and product considerations

4. Silicon: Special properties and emerging technologies, Silicon on insulator; microsystems and etching of Si; electrochemical etching, porous Silicon
5. and applications, amorphous Si and applications, SiGe: Materials aspects and devices
6. GaAs: Basics and Fundamentals of Optoelectronics: structural and theoretical aspects; crystal growth, technology; fundamentals of light absorption and emission; optoelectronic devices: fundamentals; semiconductor Lasers
7. III-V semiconductors: Materials and Device Aspects: GaP and InSb, GaN; quantum wells and heterostructures
8. Special Semiconductors, Applications and Technologies: SiC, and diamond; II - VI, Se, CuInSe2 and relatives; semiconducting polymers; special applications (Peltier elements, thermoelectronc generator, ...)

literature:
recommended: Master 3rd semester
examination: oral

course: ***Sensors***

type: lecture + exercises *lecturer:* Weppner
semester: SS
hours per week: 3 *ECTS credits:* 4
content:

1. Fundamentals: ideal and real crystals
2. Bulk Effects
3. Surface Effects: oxide semiconductors (Figaro-sensor)
4. Ionic Junctions: galvanic elements with liquid and solid, ionic conductors, amperometric, coulometric and kinetic sensors
5. Electronic Junctions: FETs, catalytic metal gates
6. Surface Acoustic Waves
7. Optical Sensors
8. Biochemical Interactions
9. Non-linear Electronic Resistances
10. Magnetic Effects
11. Thermal / Calorimetric Sensors
12. Mechanical Sensors: Capacitive and Inductive Effects
13. New Principle and Technologies Multisensors, Smart Sensors

literature:
recommended: Master 2nd semester
examination: oral

course: ***Silicon Technology I + II***

type: lecture *lecturer:* Heuberger , Bernt
semester: SS+WS

hours per week: 2 (fortnightly)each semester *ECTS credits:* 2,5 each semester

content: The semiconductor technology is concerned with the fabrication of semiconductor devices and integrated circuits. Because of their technical importance the methods for doping, la yer modification and structure generation in highly integrated silicon-ICs are emphasized. To make clear the economic aspects of integration the historical development of the technology is treated in the lecture. The two parts of the course can be attended independently.

literature:
1. D. Widmann, H. Mader, H. Friedrich
Technologie hochintegrierter Schaltungen, Springer Verlag
2. R. Müller, Bauelemente der Halbleiterelektronik, Springer Verlag

recommended: Master 2nd semester, Basic semiconductor device physics

examination: oral

course: ***Solid State Physics for Engineers I+II***

type: lecture + exercises *lecturer:* Adelung, Faupel

semester: WS+SS

hours per week: 3 each semester *ECTS credits:* 4 each semester

content: 0. Fundamentals of Quantum Mechanics: mathematical tools, quantum mechanical axioms and operators, Schrödinger equation
1. Chemical Bonds in Solids: covalent bond, ionic bond, van der Waals bond, hydrogen bond, metallic bond
2. Crystal Structure: translational lattice, symmetry, simple crystal structures, the effect of defects on physical properties, noncrystalline solids
3. Diffraction by Solids: crystalline solids and reciprocal lattice, structure factor, diffraction by noncrystalline solids, experimental methods, diffraction at surfaces
4. Dynamics of crystal lattices: lattice vibrations, thermal properties of crystals, thermal expansion, thermal conduction by phonons, phonon spectroscopy
5. Electrons in solids
5.1 Free electron model Free electron gas and Fermi statistics, specific heat of metals, thermionic emission from metals
5.2 Energy bands in solids Approximation of quasi free electrons, examples for band structures and density of states
5.3 Influence of external fields Effective-mass, hole concept, electrical conductivity of metals, thermoelectrical effects, contact potential, Wiedemann-Franz law
6. Semiconductors Intrinsic semiconductors, doping, experimental methods to determine electronic properties of semiconductors and metals, amorphous semiconductors, p-n junctions, heterostructures and super lattices
7. Magnetic Properties Diamagnetism, paramagnetism, ferro- and antiferromagnetism
8. Dielectric Properties Dielectric constant and polarizability, optical properties, ferroelectric solids, experimental methods to determine the dielectric function

literature:
1. Ch. Kittel, Introduction to Solid State Physics, John Wiley & Sons, New York 1996
2. H. Ibach and H. Lüth, Solid State Physics, Springer, New York 1995

3. N.W. Ashcroft, N.D. Mermin, Solid State Physics, Saunders College Publishing , New York 1976

recommended: Master 1st and 2nd semester

examination: written

course: ***Statistical Methods in Materials Science***

type: lecture + exercises *lecturer:* Carstensen

semester: SS

hours per week: 3 *ECTS credits:* 4

content: In phenomenological the laws of thermodynamics and thermodynamic potentials will be discussed.
The Legendre-transformation for the calculation of the thermodynamic potentials for different contacts is introduced and applied for several examples centering around the physical interpretation of the entropy.
The statistical approach for the calculation of the partition function for the evaluation of the thermodynamic potentials will be presented on the example of the specific heat capacity.
This fundamentals will be used for the calculation of phase diagrams, formation entropy of dislocations and voids, and spontanic magnetization. Concepts will be discussed, how nonequilibrium processes can be described in terms of the equilibrium thermodynamic formalism.
The Semiconductor-LASER and the Boltzmann-equation for current and diffusion processes will be dealt in detail.

literature:
1. S.M. Sze, Physics of Semiconductor Devices, John Wiley & Sons, New York 1981
2. Ashcroft/Mermin, Solid state physics, Saunders College Publishing
3. P.S. Kirejew, Physik der Halbleiter, Akademischer Verlag Berlin, 1974
4. Wolfgang Weidlich, Thermodynamik und statistische Methoden, Akademische Verlagsgesellschaft, Wiesbaden 1976
5. Albrecht Winnacker, Physik von Maser und Laser, BI Wissenschaftsverlag, Zürich 1984

recommended: Master 4th semester, A general understanding of the statistical thermodynamics and its applicability to solid state physics

examination: oral

course: ***Surface Analysis Methods***

type: lecture *lecturer:* Weppner, Chu

semester: SS

hours per week: 2 *ECTS credits:* 2.5

content: 1. Structure and Composition of Solid Surfaces
2. Ultrahigh Vacuum
3. Electron Microscope
4. SIMS - Secondary Ion Mass Spectrometry
5. Auger Electron Spectroscopy
6. Vibrational Spectroscopy
7. Rutherford Backscattering Spectrometry
8. Low Energy Ion Scattering
9. Low Energy Electron Diffraction
10. Ultraviolet Photoelectron Spectroscopy
11. EXAFS

recommended: Bachelor Materials Scientists 6th Semester

literature: J.C. Anderson, K.D. Leaver, R.D. Rawlings and J. M. Alexander, Materials Science
D.J. O'Connor, B.A.Sexton, R.ST.c. Smart, Surface Analysis Methods in Materials Science
Peter W. Atkins, Physical Chemistry Walter J. Moore, Physical Chemistry

examination:

course: ***Thermodynamics and Kinetics I+II***

type: lecture + exercises *lecturer:* Weppner

semester: SS + WS

hours per week: 3 each semester *ECTS credits:* 4 each semester

content:

1. Phenomenological Thermodynamics: Gibbs' Representation, Multicomponent- / Multiphase Systems, Thermodynamics of Disorder
2. Determination of Thermodynamic Data: Calorimetry, Multiphase Equilibria, EMF-Methods, Heat Capacities, Examples
3. Statistical Thermodynamics: Boltzmann-, Fermi-Dirac- and Bose Einstein-Statistics, Determination of Phenomenological Parameters
4. Phase Diagrams:
   One- and Two-Component Systems, Determination of Phase Equilibrium Diagrams, Phase Analysis, Multinary Systems, Non-Equilibrium Phases
5. Fundamentals of Irreversible Thermodynamics:
   Onsager-Relations, Matter in Temperature Gradients
6. Solid State Kinetics:
   Atomic Motion, Transport in Electrical and Chemical Potential Gradients, Component, Tracer- and Chemical Diffusion, Onsager-Relations, Sintering
7. Solid State Reactions:
   Nucleation Growth, Transformation Kinetics, Chemical and Electrochemical, Corrosion

literature:

1. D.V. Ragone, Thermodynamics of Materials, Wiley & Sons, New York, 1995
2. O. Kubaschewski, C.B.Alcock, P.J. Spencer, Materials Thermochemistry, Pergamon Press, Oxford, 1993
3. P.W. Atkins, Physical Chemistry, Oxford University Press, Oxford, 1992
4. C.G. Bergeron, S.H. Risbud, Introduction to Phase Equilibria in Ceramics
5. H. Schmalzried, Chemical Kinetics of Solids, VCH, Weinheim, 1995
6. H. Rickert, Electrochemistry of Solids, Springer-Verlag, Berlin-Heidelberg-New York, 1982

recommended: Master 1st and 2nd semester

examination: written

course: ***Thin Solid Films I***

type: lecture + exercises *lecturer:* Rätzke

semester: SS

hours per week: 3 *ECTS credits:* 4

content:

1. Introduction and Overview

2. Vacuum Physics and Technology: kinetic theory of gases, gas transport, vacuum pumps and systems
3. Thin Film Deposition Methods: thermal evaporation, sputtering, laser ablation, chemical vapor deposition
4. Basic Properties of Thin Films: film thickness, homogeneity, conformity, and composition
5. Thin Film Growth: physisorption, diffusion, chemisorption, nucleation
6. Characterization of Thin Films: Selected methods
7. Epitaxy: homoepitaxy, heteroepitaxy, misfit, methods for depositing epitaxial films, epitaxial film growth
8. Microstructural Evolution: structure zone models, grain structure, amorphous thin films
9. Interdiffusion and Reactions in Thin Films: phase formation, lattice, grain boundary and dislocation diffusion, metal-semiconductor reactions, diffusion barriers
10. Mechanical Properties of Thin Films: elasticity, plasticity, stress, adhesion, hardness and fracture, wear resistance
11. Electromigration in Thin Films
12. Film-Patterning Techniques

literature:
recommended: Master 2nd semester
examination: written

course: ***Thin Solid Films II***

type: lecture + exercises *lecturer:* Rätzke
semester: WS
hours per week: 3 *ECTS credits:* 4
content: Microstructural evolution,
Interdiffusion, Reactive diffusion,
Mechanical Properties
Electrical, magnetic, optical properties selected topics
literature: -M. Ohring, The Materials Science of Thin films, Academic Press, 1992
-D.L. Smith, Thin Film Deposition, McGraw Hill, 1995
-K.N. Tu et al. Electronic Thin Film Science, Macmillan, 1992
-R.C. O'Handley, Modern Magnetic Materials, Wiley, 2000
recommended: Master 3rd semester, Thin Solid Films I
examination: written

D. LIST OF LECTURERS

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e-mail: ww@tf.uni-kiel.de

E. GENERAL INFORMATION FOR INTERNATIONAL STUDENTS

I. APPLICATION FOR THE MASTERS STUDY COURSE

1. Application documents

Please use the forms you will find at the end of this brochure and send them to
KielMat International
Technische Fakultaet
Christian-Albrechts-Universitaet zu Kiel
Kaiserstrasse 2,
D-24143 Kiel, Germany.

2. Admissions procedures

2.1. German citizens

Applicants who are German citizens, i. e. who have a dual citizenship, with a diploma or B.Sc. should send the certified copies of their academic transcript, their degree certificate, and their English certificate to

KielMat International
Technische Fakultaet
Christian-Albrechts-Universitaet zu Kiel
Kaiserstrasse 2,
D-24143 Kiel, Germany.

After verification the applicants will receive a certificate of qualification. With this certificate you can apply directly here:

Rektorat der Christian-Albrechts-Universität zu Kiel
Zulassungsstelle
Christian-Albrechts-Platz 5
D-24098 Kiel

A complete set of application documents has to be presented at Kiel University by July 15

2.2. Non-German applicants

International applicants with a B.Sc. or similar degree from outside Germany send a completed and signed application form as well as complete application documents to the following address:

KielMat International
Technische Fakultaet
Christian-Albrechts-Universitaet zu Kiel
Kaiserstrasse 2,
D-24143 Kiel, Germany.

A complete set of application documents has to be presented at Kiel University by April 15.
All applications which are received later than the above-mentioned dates can not be considered.

Please check the above-mentioned list to ensure that you have enclosed all the necessary documents before sending off your application as we will not ask for missing documents. If your application is not complete, it will be rejected. Certified copies of the following documents and their translations must accompany the application form for admission. Certificates in English need not be translated. Please do not send us originals, as the enclosed copies will be destroyed in case your application is rejected.

- Completed and signed application form.
- Certificate of completed schooling, which qualifies the applicant to study at a university in his or her home country, including an overview of grades and subjects.
- Report or certificate of a university entrance examination passed in a foreign country and/or proof of registration from a university (including a complete list of grades), if applicable.
- University transcripts including a list of subjects and grades.
- Certificate of a completed bachelors course or similar degree
- Verification of proficiency in English. We accept TOEFL, Cambridge Proficiency Certificate, or IELTS.
- Curriculum vitae, including a complete overview of the applicant's education.
- A letter of purpose, explaining why the applicant wants to join the Masters Program in Materials Science and Engineering in Kiel and what are his future plans
- Applications from China will only be accepted if the certificate from the Academic Examination Board is enclosed (see below)

Important notice: We cannot give you any information about the status of your application before the 1st May!

2.3. Applicants from PR of China

Every applicant from China has to apply at the Academic Examination Board in Beijing prior to his application to Kiel University.
A Bachelor's degree is requested as a prerequisite for admission. On receipt of our letter of admission, you may apply for your visa at the Academic Examination Board. This avoids asking for an appointment at the visa office. The application for an academic examination as well as the application for a visa has to be addressed to the following address

Kulturreferat der Deutschen Botschaft Peking
Akademische Prüfstelle/ Academic Examination Board
Landmark Tower 2
8 Dongsanhuanbeilu, Office 0311
Chaoyang District
100004 Beijing

II. SOCIAL FEES, HEALTH INSURANCE, COST OF LIVING, ACCOMONDATION, FINANCING

1. Social fees

The exemption from paying tuition fees also applies to international students studying at Kiel University. However, a social fee must be paid each semester which currently amounts to 91.00 Euro which includes free bus transportation.

2. Health insurance

According to § 5 Section 1 No. 9 SGB V, students of German universities can obtain health insurance from a statutory health insurance scheme or an alternative health insurance scheme until the end of the 14th semester of their course of study and until they are 30 years old. International students can apply for an exemption from the statutory health insurance scheme if they are insured by a private health insurance scheme or if they present proof that health insurance from their home country is valid in the Federal Republic of Germany and that it provides the same coverage as a statutory health insurance scheme. For students, the monthly contributions for the statutory health and supplementary nursing care insurance currently amount to approximately € 50.00 per month.

3. Cost of living

The cost of living differs at universities in various cities. International students studying at Kiel University must assume that their monthly expenses will amount to about € 620 per month. This amount can be broken down as follows:

Health insurance and social fee (approx.)	€ 75.00
Rent (approx.)	€ 180.00
Groceries, clothing and other needs (approx.)	€ 320.00
Study materials, books (approx.)	€ 50.00
Total (approx.)	€ 625.00

Furthermore you need between € 300 and € 900 as a deposit for your room or flat.
There is no tuition fee.

4. Accommodation

Many international students ask the International Office to help them obtain a room in a dormitory. Unfortunately, we can only help a small number of these students to obtain this kind of housing. The dormitories do not belong to the University of Kiel, but to other organizations. The number of rooms is, however, smaller than the demand. For this reason, most international students cannot expect to get a dormitory room. It is also difficult to find private housing at a reasonable price. We recommend that you arrive in Kiel one month before the beginning of your studies in order to find accommodation. A list of student dormitories is available on the internet (http://www.uni-kiel.de/international/betreuung_e/impliv.shtml).

Please send your application form for student housing in time directly to

Studentenwerk Schleswig-Holstein
- Wohnheimverwaltung -
Westring 385

D 24 118 Kiel
Germany

email: Internationales@Studentenwerk-S-H.de
http://www.uni-kiel.de/stwsh/soziales/internationales.htm

The renting periods in the dormitories are currently at least six months. The renting contracts always have to be signed for these six months for the winter semester from September 1st of a given year until February 28th of the following year.

5. Financing

It is absolutely necessary to secure financing for the duration of your studies in the Federal Republic of Germany before departure. German authorities abroad will issue a residence permit for studying purposes only if the student has sufficient proof that he or she has at least € 600.00 available on a monthly basis.
We cannot provide scholarships on a regular basis. Sometimes special scholarships for Baltic students are available. From time to time we are offering lab jobs (30 hours/month, approx. € 230/month), too. Please check our website regularly.

KielMat International

Christian-Albrechts-Universität zu Kiel

- Technische Fakultät der Christian- Albrechts-Universität -

IMPORTANT: PLEASE USE BLOCK LETTERS IF YOU CANNOT PRINT OR TYPE. WE WILL NOT BE RESPONSIBLE IF WE CAN NOT IDENTIFY YOUR ADDRESS OR YOUR E-MAIL ADDRESS.

The application shall be filled out completely and returned to KielMat International, Technische Fakultät der Christian-Albrecht-Universität, Kaiserstrasse 2, D 24143 Kiel, Germany. Incomplete applications will not be considered.

Application deadline: 15th April 2005

Application for Admission to the Master of Science in Materials Science and Engineering

For the academic year 2005/06

Passport Photo

1. PERSONAL INFORMATION (Please print)

Family name:			
Given name:			
Nationality/ Citizenship			
Place of birth:		**Country:**	
Date of birth: (day/month/year)		**Native language:**	

Sex: ☐ **male** ☐ **female**

Marital status: ☐ **single** ☐ **married** ☐ **number of children**

Permanent address (address to which correspondence should be sent):

e-mail address:

Telephone:		**Fax:**	

2. EDUCATIONAL BACKGROUND

Please attach **certified** copies of certificates to this application form.

2.1 High School Education/ Comprehensive secondary school/ Grammar school (IMPORTANT: Please attach certified and translated copy)

What is the highest level of your high school education?
(G.C.E. (O + A-Level), baccalaureat, Lise Diplomasi, Apolyterion, 2° Grau, High School Diploma, etc.)

Place and date of graduation (day/month/year):

2.2 University Admission Exam (Please attach certified and translated copy)

Have you taken a university admission exam in your home country?

☐ yes ☐ no

If yes: Date: and Name:

IMPORTANT: Please include all necessary documents for university admission in your home country!

2.3 Description of University Education (not in Germany)

At which universities have you studied? Please include official transcripts listing all classes.
IMPORTANT: For transcripts in languages other than German or English please attach an **officially authenticated** translation.

1.	Name of University	Department	Language of instruction	From/To
	Degree obtained	Grade Point Average	Maximum Possible Grade	Lowest Passing Grade
2.	Name of University	Department	Language of instruction	From/To
	Degree obtained	Grade Point Average	Maximum Posssible Grade	Lowest Passing Grade

2.4 German Universities/ Fachhochschulen

At which universities/ Fachhochschulen have you studied?

1.	Name of University	Department	Language of instruction	From/To
	Degree obtained	Grade Point Average	Maximum Possible Grade	Lowest Passing Grade
2.	Name of University	Department	Language of instruction	From/To
	Degree obtained	Grade Point Average	Maximum Possible Grade	Lowest Passing Grade

3. LANGUAGE SKILLS

3.1 English

Which English examination did you attend?

☐ TOEFL (Paper-Based) Score ☐

☐ TOEFL (Computer-Based) Score ☐

☐ Cambridge Proficiency Certificate

☐ IELTS Score ☐

IMPORTANT: Please enclose certificate in **certified** form.

3.2 German (knowledge is not compulsory for admission)

Which German language class did you attend?

Where:	
When:	
How many hours:	
Certificate obtained:	

IMPORTANT: Please enclose certificate in **certified** form.

4. PROFESSIONAL EXPERIENCE

Job description	
Company	
City/State/Country	
From/to	

5. APPLICANTS FROM PR CHINA

Applications from China (Hong Kong excluded) will only be accepted if the certificate from the Academic Examination Board is enclosed. This means that every applicant from China has to apply at the Academic Examination Board prior to his application to Kiel University.
A Bachelor's degree is requested as a prerequisite for admission.
On receipt of our letter of admission, you may apply for your visa at the Academic Examination Board. This avoids asking for an appointment at the visa office.
The application for an academic examination as well as the application for a visa has to be addressed to the following address

Kulturreferat der Deutschen Botschaft Peking, Akademische Prüfstelle, Landmark Tower 2,
8 Dongsanhuanbeilu, Office 0311,Chaoyang District, 100004 Beijing

6. FINANCING OF YOUR STUDIES (voluntary statement)

Have or will you apply for financial assistance? ☐ yes ☐ no

If yes, where?

Have you received financial assistance? ☐ yes ☐ no

If yes, from which granting institution and in what amount?

If no, from which granting institution were you turned down?

Other sources of funding

7. REFEREES

Please give the names and addresses of two referees below. Your referees should provide a reference of your academic ability as a postgraduate student. You are responsible for ensuring that the letters of recommendation reach the University of Kiel by April 15th.

A.	Name			
	Address			
	Post Code			
	Telephone No.		Fax No.	
	e-Mail			

B.	Name			
	Address			
	Post Code			
	Telephone No.		Fax No.	
	e-Mail			

I ensure that all statements are complete and correct. The mentioned documents are appended. I am aware that careless or willful false statements are misdemeanor and will lead to an exclusion from the university admission procedure or - when later detected - university admission.

Place Date (day/month/year) Signature

Please don't forget to attach

- a curriculum vitae (1 page)
- a statement of purpose (1 or 2 pages)!

KielMat International

Christian-Albrechts-Universität zu Kiel

- International Office / Akademisches Auslandsamt -

Olshausenstraße 40 - D-24098 Kiel

Letter of Recommendation

Full name of the applicant: _____

Title of programme of study: Master of Science
(in Materials Science and Engineering)

TO THE REFEREE **URGENT**

The above named student is applying for postgraduate study at Kiel University and has named you as a referee. We would be grateful if you could complete this form and return it to the above-mentioned address as soon as possible.

Name of Referee _____
Position _____
Address _____

_____
Post Code _____
Telephone No. _____ Fax No. _____
E-Mail _____

How long and in what capacity have you known the applicant?

_____
_____
_____
_____

It would be helpful if you could give the result of any examinations taken or predict the result of examinations to be taken.

_____
_____
_____

If the applicant's first language is not English, please comment on his/her level of competence.

	Excellent	good	fair	poor
written	☐	☐	☐	☐
listening comprehension	☐	☐	☐	☐
spoken	☐	☐	☐	☐
reading	☐	☐	☐	☐

REFEREES CONFIDENTIAL REPORT

Please provide comments on the academic suitability of the candidate for the proposed programme of study.

Signature _____ Date _____

Institution / University official stamp

Thank your for your time and cooperation in completing this reference form.

Please return the completed form as soon as possible to

KielMat International
Technische Fakultaet
Christian-Albrechts-Universitaet zu Kiel
Kaiserstrasse 2,
D-24143 Kiel
Germany.
E-Mail: application@kielmat.com

Application for a room in a student housing of the Studentenwerk Schleswig-Holstein

Studentenwerk Schleswig-Holstein
- Wohnheimverwaltung -
Westring 385

24 118 Kiel

Eingang bei STW
Eingang der Gebühr:
☐ ja ☐ nein
erfaßt am:
Namenszeichen:
(This part will be filled in by the housing department only)

Dear applicant,

this application will be worked on as fast as possible, to ensure this process we will use an electronic data appliance. This form must be filled in thoroughly, completely and readably (type or CAPITAL LETTERS). Applications, which are not complete, will be refused. Your personal data should be indicated on the back of this form.

I hereby apply for: (please tick)
☐ **winter semester 2003 / 2004 (from 01-09-2003 onwards)**
☐ **summer semester 2004 (from 01-03-2004 onwards)**

Would you like to move in earlier than at the above mentioned dates? ☐ yes ☐ no

Please tick here your housing preferences: (For detailed information see: www.studentenwerk-s-h.de)

☐ a room in a student housing in **Kiel**
  (additionally for students of Fachhochschule)
  ☐ Dr.-Schlüter-Göttsche-Stiftung (Jägersberg 14)
  ☐ Dietrichsdorf (situated in immediate proximity of the Fachhochschule)
☐ a room in a student housing in Flensburg
☐ a room in a student housing in Eckernförde
☐ a room in a student housing in Heide
☐ a room in a student housing in Wedel
☐ a room in a student housing in Lübeck

After my moving in, I will send a proof of matriculation from an institution of higher education in Schleswig-Holstein to the housing administration. I will indicate my personal data on the back of this application form. I do take note that all data indicated at the back of the form are voluntarily given. I am aware that an incomplete application form might lead to a refusal of the application.
The data of this application are registered with electronic data processing, dealt with and sent to a committee for approval.
I hereby agree with giving a direct debit authorization to the Studentenwerk Schleswig-Holstein, to charge the rent monthly from my account in case of them offering me a tenancy agreement.
Personal preferences for specific student housing will be considered depending on the places available. We will offer you an alternative booking, if places in your preferred student housing are not available. After one semester of living in this alternative student accommodation, you might post a claim for moving into the student accommodation of your choice.

_____ _____
place, date Your signature

Would you please fill in your personal data:

Surname: _____

Name: _____

Are you male ☐ / female ☐ (please tick)

Birthday - Day:_____ Month:_____ Year:_____

What is your nationality ? _____

Actual address (address for correspondence):

Street:_____

Postal Code / Town:_____

Telephone:_____

Mobile:_____

E-mail:_____

If different from above: What is your home address (i.e. address of parents' house)

Street:_____

Postal Code / Town:_____

Telephone:_____

At which university are you enrolled or will you be enrolled in Germany ?

_____

Are you starting your studies (are you a first semester student ?) in Germany ? Yes ☐ No ☐

Which subject are you studying ?_____

Number of semesters / years at university in Germany:_____

Have you lived in a student accommodation of Studentenwerk Schleswig-Holstein before?

From: _____ Until: _____

Do you have any reasons to be preferably chosen to enter a student housing (disability / medical report)? If so, please enclose a detailed medical report as well as a personal explanation, pointing out the reasons why your application should be considered in preference.

☐ application to be considered in preference

☐ medical report / disabled persons identity card / explanation enclosed!

Do you have special preferences concerning your room ?

☐ furnished ☐ non-furnished ☐ maximum price for the room _____ €

Location / name of the specific student accomodation: (Information see: www.studentenwerk-s-h.de)

_____