Welcome to Stuttgart and we hope that you have a very pleasant and rewarding stay.

Your Office of International Affairs

B. Materials Science Education at the Universität Stuttgart

1. Materials Science

The importance of materials to the growth, prosperity and quality of life of humans is well documented in our habit to name developmental time periods after materials: stone age, bronze age, iron age. Nevertheless, materials science is still a young and intensely developing science. Nowadays the improvement of existing and the developing of new materials are counted among the major driving forces for economic growth: Neither the specially coated frying pan, the shape-memory spectacle frame, the long-lasting hip-joint and dental prostheses, nor the interconnection lines in computer chips would be feasible without the *right* material.

Materials Science is an interdisciplinary science. It has been developed based on natural (physics and chemistry) and engineering sciences. A materials scientist seeks to explain and to control one or more of the four basic elements as described e.g. by M.C. Flemings and R.W. Cahn (Acta mater. 48 (2000) 371-383):

- The structure and composition of a material; including the type and arrangement of atoms and lattice imperfections as viewed over the range of length scales (nano-, meso-, micro-, macro-scale).
- The synthesis and processing by which the particular arrangement of atoms and lattice defects is achieved.
- The properties of the material which result from the arrangement of atoms and lattice defects and make the material interesting or useful.
- The performance of the material, that is, the measurement of its usefulness in actual conditions, taking account of economic and social implications.

Materials science research in Stuttgart focuses on the fundamental understanding of the relation among synthesis, microstructure and properties. On the basis of experiments theoretical models are developed which in turn lead to predictions that can be experimentally verified. Thus tailoring of material properties becomes feasible. This attitude is also taught to the students of the course of study “Materials Science”.

2. The Institutes: Their Teaching and Research Fields

The course of study “Materials Science” at the Universität Stuttgart is housed within the Faculty of Chemistry. In the course students are educated in the basics of natural sciences and engineering and are trained to successfully solve material-related as well as technological problems. Beside lectures, exercises and seminars, laboratory courses are of special importance in education. The aim is thus to train the students in analytic-methodical thinking and problem solving and to qualify them for work in an interdisciplinary and international team.

The Stage-2 studies (Hauptstudium) are planned to be successfully finished within five semesters. Four semesters are reserved for lectures, exercises, seminars and laboratory courses. The fifth semester is used to complete the final thesis, the so-called diploma thesis (Diplomarbeit). More details on the Stage-2 studies are given in Part C of this information package.

Two institutes are mainly involved in the education at the Stage-2 studies: the Institute of Physical Metallurgy (Institut für Metallkunde) and the Institute of Nonmetallic Inorganic Materials (Institut für Nichtmetallische Anorganische Materialien).

2.1 The Institute of Physical Metallurgy (Institut für Metallkunde)

The Institute of Physical Metallurgy was founded in 1935. It consists of two chairs. The chairholders have a dual responsibility. Beside being full professors at the Universität Stuttgart, they are directors at the Max-Planck Institute for Metals Research (Max-Planck-Institut für Metallforschung). This arrangement trades back to the thirties of the last century and has proven to be immensely successful. Students experience the international and interdisciplinary character of research and benefit from the latest up-to-date equipment and the newest research results.

- **Institute of Physical Metallurgy, 1st chair (Institut für Metallkunde, 1. Lehrstuhl)**

Chairholder: Prof. Dr. E. J. Mittemeijer
Address: Heisenbergstr. 3
70569 Stuttgart, Germany
Internet: http://www.uni-stuttgart.de/imtk/lehrstuhl1/index.html

The research activities at the first chair concern the thermodynamics and kinetics of phase transformations, especially in thin films. Furthermore, ample attention is devoted to the energetics and kinetics of grain boundaries, and metal-gas reactions. Current research topics are for example:
- thermodynamics and kinetics of phase transformations,
- phase transitions in interstitial solid solutions,
- diffusion and stress in thin films,
- metal-gas reactions (high-temperature oxidation, nitriding),
- microstructure of and phase transformation in heavily deformed materials.

The facilities associated with the first chair include different X-ray diffraction techniques (to determine texture, internal stresses, crystallite size and strain, lattice parameters and crystal structures), various techniques for surface chemistry and thin film analysis (Auger Electron Spectroscopy, X-ray Photoelectron Spectroscopy, ellipsometry) as well as calorimetric apparatus.

The teaching activities of the first chair comprise thermodynamics and kinetics of materials as well as surface engineering. Details are given in Part C of this information package.

- **Institute of Physical Metallurgy, 2nd chair**
  (Institut für Metallkunde, 2. Lehrstuhl)

Chairholder: Prof. Dr. E. Arzt

Address: Heisenbergstr. 3
70569 Stuttgart

Internet: http://www.uni-stuttgart.de/imtk/lehrstuhl2.html

Research focuses on the mechanical properties of structural materials, the mechanical properties of thin films, metal foams, electromigration and mechanical properties in biological systems. Especially, the relations between microstructure and properties are investigated. The interpretation of these relations and the development of theoretical models eventually allow the prediction of materials properties. Examples are:

- high-temperature alloys and metal-matrix composites,
- mechanical characterization by mechanical spectroscopy and acoustical methods,
- microstructural and size effects in small-scale materials,
- mechanical and electrical reliability of microcomponents,
- continuum-mechanical and atomistic modeling,
- structure, micromechanics and tribology of biological surfaces.

The equipment consists of a number of mechanical testing methods as for example tensile and compressing testing, creep, fatigue, thermomechanical fatigue, and crack propagation, nanoindentation, substrate curvature measurement and focused ion-beam microscopy. Also numerous non-destructive techniques such as modern ultrasonic testing or acoustic emission measurement and X-ray diffraction for stress and texture measurement. To a considerable extent this equipment is also used in the education of students of materials science in laboratory courses.

The teaching activities of the second chair cover mechanical and electronic properties of materials, materials analysis, and the physical metallurgy of metals and alloys. Details are given in Part C of this information package.

2.2 The Institute of Nonmetallic Inorganic Materials (Institut für Nichtmetallische Anorganische Materialien)

Chairholder: Prof. Dr. F. Aldinger

Address: Heisenbergstr. 3
70569 Stuttgart, Germany

Internet: http://aldix.mpi-stuttgart.mpg.de/

The Institute of Nonmetallic Inorganic Materials was founded in 1992. Also the chairholder of this institute is at the same time a full professor at the university and a director at the Max-Planck Institute. At the center of the research work of this institute is the search for new materials with outstanding properties and property combinations. For this purpose, the work is concerned with:

- fundamental investigations of the reaction mechanisms of known and new materials synthesis techniques,
- phase studies of complex materials systems, i.e. experimental and computational determination of stable and metastable phase equilibria,
- the generation and characterization of defined microstructure and
- the study of materials properties and the interaction between microstructure and properties.

The Institute of Nonmetallic Inorganic Materials is responsible for the subject "Ceramics" within the course of study of Materials Science. Details are given in Part C of this information package.

2.3 Institute of Applied Macromolecular Chemistry (Institut für Angewandte Makromolekulare Chemie)

Director: Prof. Dr. C. D. Eisenbach

Address: Pfaffenwaldring 55
70596 Stuttgart, Germany

Internet: http://www.uni-stuttgart.de/iamc

The foundation of the Institute dates back to 1953 when a new chair for General Chemical Technology with emphasis on pigments and coatings was installed followed by establishing the Institute of Chemical Technology II; the Institute was renamed Institute of Applied Macromolecular Chemistry (IAMC) in 1999. The holder of the chair of Macromolecular Chemistry is at the same time the Director of the IAMC and Head of the Research Institute for Pigments and Coatings (FPL) which has been founded in Stuttgart in 1951 by the paints and varnish industry.
The research at the Institute of Applied Macromolecular Chemistry tries to find new solutions for current technological and polymer material related problems and, by interdisciplinary methods, investigates novel materials that are based on polymers. The key to the development of new polymer materials with special and/or unusual properties is to control the molecular structure and to understand structure-properties relationships. These aspects are especially emphasised in the research projects pursued at the IAMC. Major topics include the generation of supramolecular architectures of macromolecules, the study of intra- as well as intermolecular interactions in tailored macromolecular and particulate systems, polymer blends and nano-composites, photoactive polymers, and finally the establishing of structure-properties relationships in structural and functional polymer materials on a molecular scale.
The main objective of the teaching at the Institute of Applied Macromolecular Chemistry is to convey basic knowledge about synthesis and properties of macromolecular systems and polymer analysis, and to elucidate the relationships between the molecular structure of polymers and their molecular constitution in bulk and liquid phase as well as the resulting material properties.

2.4 Institute of Fibre and Textile Chemistry (Institut für Textil- und Faserchemie)

Director: N.N.
Address: Pfaffenwaldring 55
70569 Stuttgart, Germany
Internet: http://www.uni-stuttgart.de/itf/

Research at the institute centers on the synthesis, characterization and production technology of new or improved polymer materials.
This includes in particular the synthesis of fibre polymers, spinning of synthetic fibers, specialty fibers with high modulus, high-tenacity, elastomeric or ceramic fibers, fiber reinforced composites and the investigation of structure-property relationships.

2.5 Institute of Physical Chemistry (Institut für Physikalische Chemie)

Directors: Prof. Dr. H. Bertagnolli
Prof. Dr. E. Roduner
Address: Pfaffenwaldring 55
70569 Stuttgart, Germany
Internet: http://www.ipc.uni-stuttgart.de/index_d.html

- **Research group: Prof. Dr. Helmut Bertagnolli**
Internet: http://www.ipc.uni-stuttgart.de/bertagnolli/index.html

The research activities deal mainly with the characterisation (structure, local order, dynamics) of various types of materials - such as liquids and amorphous solids as well as solutions and multi-component systems - which are of great interest in different areas of basic research and application. The experimental techniques employed here are X-ray and neutron diffraction, fast X-ray diffractometry, EXAFS-spectroscopy and differential scanning calorimetry. Statistical-mechanical calculations (Monte Carlo simulations) complete the molecular description of the various amorphous systems examined here. Current research topics are:
- determination of the local order in amorphous systems
- (molecular liquids, sols, gels, supercritical systems, salt melts),
- structural characterisation of thin layers,
- dynamics of molecular liquids,
- molecular interactions in liquids,
- metal-organic compounds and glasses,
- computer simulation of amorphous structures.

➢ Research group: Prof. Dr. F. Gießelmann

Internet: http://www.ipc.uni-stuttgart.de/giesselmann/index.html

Our central field of research is the physical chemistry of liquid crystals. Liquid crystals are partially ordered, anisotropic fluids which are today widely used as electro-optic materials in the LCD ("Liquid Crystal Display") devices of, e.g., computer notebooks and mobile phones. We are investigating the relations between the molecular order and the macroscopic properties of liquid crystals by X-ray diffraction, polarizing microscopy, differential scanning calorimetry, dielectric spectroscopy and electro-optic experiments. Examples from our ongoing research activities are:

- the phase transitions and electro-optic phenomena in ferro-, ferri- and antiferroelectric phases of smectic liquid crystals,
- the photoferroelectric effect, where the spontaneous electric polarization of a ferroelectric liquid crystal host phase is modulated by the photo-isomerization of photochromic dopant molecules,
- the impact of molecular chirality on the structure and the properties of liquid crystalline phases, and
- the molecular self-assembly in the liquid crystalline states of amphiphiles and certain biological molecules.

Teaching activities cover courses in general physical chemistry as well as courses in soft condensed matter, liquid crystals, and phase transitions.

➢ Research group: Prof. Dr. Klaus Müller

Internet: http://www.ipc.uni-stuttgart.de/mueller/index.html

The research focuses on the evaluation of molecular properties of various materials by employing spectroscopic techniques. Particular emphasis is given to the determination of the molecular structure, ordering behaviour and molecular dynamics of various types of disordered solids and their relationship to the macroscopic bulk properties of these materials (structure – property relationship). Examples are:

- various types of guest host systems (clathrates, zeolites),
- ceramic materials (non-oxide and oxide ceramics),
- molecular and liquid crystals,
- biomembranes,
- polymers.

The experimental techniques employed here comprise solid state nuclear magnetic resonance (NMR) spectroscopy, including broadline and high resolution techniques, as well as FT IR spectroscopy, which can be performed over a large temperature range (100 K < T < 450 K, in some cases up to 5 K or 1000 K). The analysis of these experiments is achieved with the help of suitable simulation programs, which account for the characteristics of the materials under investigation.

- **Research group: Prof. Dr. E. Roduner**
  Internet: http://ag-roduner.ipc.uni-stuttgart.de/AG-Roduner/index.html

We are interested in all aspects of the physical chemistry of free radicals, in particular their structures, the kinetics of their formation and of their disappearance, and also in the dynamics of their reorientation in solids and adsorbed on surfaces. Investigations are based primarily on magnetic resonance techniques. Typical topics which are investigated in our group are:

- Isotope effects in chemical reactions permit the testing of reaction rate theories and of potential energy surfaces. The light hydrogen isotope muonium with a mass of $1/9^{th}$ the mass of H is a particularly sensitive probe.
- Equilibrium and non-equilibrium (dynamic) effects of solvation can have dramatic effects on the kinetics of chemical reactions.
- We study the structure of transition metal ions and clusters and their interaction with organic molecules, aiming at a fundamental understanding of catalytic transformations in zeolites.
- A Nobel laureate in chemistry said half a century ago: “A crystal is a chemical grave yard”, implying that nothing moves and that all molecules are well aligned in rows. Today we know many cases where molecules are highly mobile in crystalline environments. We investigate the consequences of molecular dynamics in crystals and in cage environments in view of phase transitions and other properties of matter.
- Fuel cells give rise to hope as future sources of sustainable energy. We study oxidative degradation of proton conducting polymer membranes, and we have built the world’s first miniature fuel cell which runs in a microwave resonator of an ESR spectrometer, allowing us to directly monitor the processes inside the cell during its operation.

Teaching activities cover courses in general physical chemistry as well as specialised courses in size-dependent phenomena of nanomaterials and in magnetic resonance.

- **Research group: Prof. Dr. F. Zabel**
  Internet: http://www.ipc.uni-stuttgart.de/zabel/index.html

We are interested in the reaction kinetics and photochemistry of trace gases which are of importance for the chemistry of the atmosphere. These processes are investigated in a large temperature-controlled photoreactor from quartz; educts and products are analyzed using long-path IR and UV absorption and chromatographic methods. Typical topics which are addressed in our group are:

- rate constants of radical reactions, e. g. of alkoxy and peroxy radicals;
- UV absorption cross-sections, in particular of thermally unstable compounds, such as aldehydes, HC(O)Br and $IONO_2$;
- monomer/dimer equilibrium constants of (substituted) carboxylic acids.
- product distributions in more complex reaction systems.

Teaching activities cover courses in general physical chemistry and in atmospheric chemistry.

2.6 Institute of Technology of Forming (Institut für Umformtechnik)

Director: Prof. Dr. K. Siegert
Address: Holzgartenstr. 17
70174 Stuttgart, Germany
Internet: http://www.uni-stuttgart.de/ifu/

C. Course Catalogue

1. Explanation of Terms

Semester:	WS	Hours per Week:	2+1	Examination:	oral
Type:	L + E	Prerequisites:	--	Credits:	4

Semester:	recommended semester:	
	WS	= winter semester
	SS	= summer semester
	(e. o.	= every other)
Type:	L	= lecture (Vorlesung)
	E	= exercise (Übung)
	S	= seminar (Seminar)
	P	= practical (laboratory) course (Praktikum)
Examination:	written	= written exam (schriftliche Prüfung)
	oral	= oral exam (mündliche Prüfung)
	certificate	= course certificate (Schein/ erfolgreiche Teilnahme)
Credits:	The credit system is based on a mean value of 30 credits per semester.	

Prerequisites:

In the following, a description of the courses of the Stage-2 studies is given. The participation in any lecture/exercise/seminar of the Stage-2 studies requires a passed Stage-1 studies or equivalent. International visiting students are expected to have successfully completed at least two years of studies.

2. Overview on the Course of Study of Materials Science (Stage 2)

5th Semester	Credits
Materials Science I: Crystal Structure and Defects of Solids	4
Materials Science III: Thermodynamics	4
Physical Chemistry of Solids	7
Metallic Materials I	2
Polymers I	2
Elective Course	4
Laboratory: Ceramics	10
	33

6th Semester	Credits
Materials Science II: Kinetics of Solids	4
Materials Science IV: Heterogeneous Equilibria	4
Physical Chemistry III	3
Metallic Materials II	2
Polymers II	1
Seminar I	3
Elective Course	4
Laboratory: Polymers	10
	31

7th Semester	Credits
Materials Science VI: Powder Processing and Sintering	4
Materials Science VII: Mechanical Properties of Materials	4
Technology of Forming I	2
Materials Analysis I	4
Ceramic Materials I	2
Seminar II	3
Laboratory: Metals	10
	29

8th Semester	Credits
Materials Science V: Surface Engineering	1
Materials Science VIII: Electronic Properties of Materials	4
Technology of Forming II	2
Materials Analysis II	4
Ceramic Materials II	2
Seminar III	3
Colloquium on Current Topics in Materials Science	1
Laboratory: Phys. Metallurgy	10
	27

9th Semester	Credits
Final Thesis	30

3. Description of Courses (Stage-2 Studies)

3.1. Lectures

1. Materials Science I: Crystal Structure and Defects of Solids (Werkstoffwissenschaft I: Aufbau und Kristallografie)

Institute of Physical Metallurgy, 1st chair

The lecture deals with the basics of materials science: the ideal crystal structure and the deviations from it as a result of the presence of defects. It covers topics as crystallography, symmetry and its influence on physical properties, bonding in materials, point defects, dislocations, grain and phase boundaries, and crystallization of metals and alloys.

Semester:	e. o. WS	Hours per Week:	2+1	Examination:	written
Type:	L + E	Prerequisites:	--	Credits:	4

2. Materials Science II: Kinetics of Solids (Werkstoffwissenschaft II: Festkörperkinetik)

Institute of Physical Metallurgy, 1st chair

Contents: Introduction – Transport of matter – Continuum theory of diffusion – Atomic theory of diffusion – Diffusion in a concentration gradient – High-diffusivity paths – Diffiusion in ionic crystals – Diffusion in ionic semiconductors – Electromigration – Kinetics of phase transformations.

Semester:	e. o. SS	Hours per Week:	2+1	Examination:	written
Type:	L + E	Prerequisites:	--	Credits:	4

3. Materials Science III: Thermodynamics (Werkstoffwissenschaft III: Thermodynamik)

Institute of Physical Metallurgy, 1st chair

Contents: Basics of thermodynamics – Thermodynamics of solution phases – The ideal solution – The model of regular solutions – Real solutions – Experimental methods in thermodynamics – Order in solid solutions – Calculation of phase equilibria – Statistical thermodynamic models – Association model – Self-association model – Miedema model – Excess entropy of mixing.

Semester:	e. o. WS	Hours per Week:	2+1	Examination:	written
Type:	L + E	Prerequisites:	--	Credits:	4

4. Materials Science IV: Heterogeneous Equilibria (Werkstoffwissenschaft IV: Heterogene Gleichgewichte)

Institute of Nonmetallic Inorganic Materials

Phase diagrams are graphical representations of heterogeneous equilibria. The aim of the course is to enable the students to understand and apply thermodynamic rules for reading and constructing phase diagrams. Unary, binary, ternary and multicomponent systems are treated. Additionally, property and site-occupancy diagrams are introduced and links to practical applications in materials science are outlined.

Important topics are:
Basic definitions and rules (stable, metastable and non-stable equilibria, lever rule, phase rule, ...) – Examples for the relevance and application of unary and binary systems in materials science – Influence of thermodynamic interaction parameters on the topology of binary systems (Mager matrix) – Description of ternary systems: topology of 2-, 3-, and 4-phase equilibria – Invariant reactions in ternary systems (eutectic, peritectic, transition) – 3-dimensional representations, projections, isothermal sections and isopleths (temperature-concentration sections) – Scheil reaction schemes – Phase diagrams and microstructure development – Thermodynamic calculations of phase diagrams: the CALPHAD method – The lever rule and phase fraction diagrams – Scheil-Gulliver solidification for the understanding of casting alloys – Descriptions of quarternary and high-component systems – Topology of phase diagrams according to Schmalzried and Pelton – Influence of pressure on phase equilibria.

Semester:	e. o. WS	Hours per Week:	2+1	Examination:	certificate*
Type:	L + E	Prerequisites:	--	Credits:	4

* Homework will be handed in

5. Materials Science V: Surface Engineering (Werkstoffwissenschaft V: Surface Engineering)

Institute of Physical Metallurgy, 1st chair

The aim of this lecture is to give an overview on methods
(i) for coating and modification of surfaces and
(ii) for characterization of surfaces and near-surface regions.
Current research results are used to deepen the knowledge of special aspects, e.g. origin and determination of residual stresses, high temperature oxidation, nitriding, nanoindentation, depth-profile analysis.

Semester:	e. o. SS	Hours per Week:	1	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	1

6. Materials Science VI: Technology of Powder Processing and Sintering (Werkstoffwissenschaft VI: Pulvertechnologie und Sintern)

Institute of Nonmetallic Inorganic Materials

Powder technological processes and consolidation by sintering are encountered both in powder metallurgy and ceramics and lead to a diversity of state-of-the-art materials. This lecture is to convey a deepened understanding of the principles underlying the most important processing steps:
Contents: Powder production and processing – Granulometry and surface characterization – Stability of particle suspensions; rheology of ceramic slurries; filtration processes – Formulation of ceramic masses; plastic forming and dry pressing – Green body characterization and debindering – Solid state and liquid phase sintering: driving forces, sintering mechanisms, kinetics, and modeling – Microstructure development: grain growth, grain growth anisotropy, phase transformations; qualitative and quantitative analysis of microstructures.

Semester:	e. o. SS	Hours per Week:	2+1	Examination:	certificate*
Type:	L+E	Prerequisites:	--	Credits:	4

* homework will be handed in

7. Materials Science VII: Mechanical Properties of Materials (Werkstoffwissenschaft VII: Mechanische Eigenschaften)

Institute of Physical Metallurgy, 2nd chair

The course offers a comprehensive treatment of the mechanical behaviour of materials tensors, theoretical and experimental elements, and connections to applications.
Contents: Isotropic and anisotropic elastic behaviour of solids – Strain and stress tensors – Elastic constants – Inhomogeneous stress fields – Anelasticity and damping – Plastic behaviour of single and polycrystals – Strengthening mechanisms – Plasticity at high temperatures – Creep – Fracture and toughness – Composite materials – Fatigue – Mechanical properties of thin films – Mechanical phenomena in biology.

Semester:	e. o. WS	Hours per Week:	2+1	Examination:	written
Type:	L+E	Prerequisites:	--	Credits:	4

8. Materials Science VIII: Electronic Properties of Materials (Werkstoffwissenschaft VIII: Elektronische Eigenschaften)

Institute of Physical Metallurgy, 2nd chair

The electronic properties control conductivity as well as the optical and magnetic properties of materials. This course offers a comprehensive treatment of these properties and gives examples of application.

Contents: Theory of electrons – Band model – Electrical conductivity – Insulators, semiconductors and conductors – Superconductivity – Optical properties – Magnetic properties: Dia-, para- and ferromagnetism – Materials and applications.

Semester:	e. o. SS	Hours per Week:	2+1	Examination:	written
Type:	L+E	Prerequisites:	--	Credits:	4

9. Metallic Materials I
(Metallische Werkstoffe)

Institute of Physical Metallurgy, 2nd chair

Steel shows a large variation of properties. This course offers a comprehensive overview of the classification, the alloying elements, the microstructure and the mechanical properties of Fe-based alloys and gives examples of application.
Contents: Introduction to steel and Fe-based alloys – Introduction to steel – Properties of steel in comparison to other metallic materials – The system Fe-C – Microstructure of steels (austenite, ferrite, perlite, bainite, martensite) – Heat-treatment of steels – Alloying elements in steel – Hardening and tempering – Mechanical properties according to microstructure – Constructional steel – Quenched and subsequently drawn steel – Tool steel – low temperature steel – Chemical stable steel – High-temperature steel – Application and selection criteria.

Semester:	e. o. WS	Hours per Week:	2	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	2

10. Metallic Materials II
(Metallische Werkstoffe)

Institute of Physical Metallurgy, 2nd chair

This course gives a comprehensive treatment of materials selection rules and the physical metallurgy of some alloys for application under severe conditions.
Contents: Materials selection principles – Light alloys based on Al, Ti, Mg – Superalloys – Refractory alloys.

Semester:	e. o. SS	Hours per Week:	2	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	2

11. Ceramic Materials I: Structural Ceramics
(Keramische Werkstoffe: Strukturkeramik)

Institute of Nonmetallic Inorganic Materials

The manufacturing processes and properties of selected engineering ceramics are considered in some detail. Emphasis is put on materials thermochemistry, structure considerations (chemical and crystallographic), chemical, physical and mechanical properties, and on structure-property relationships. The materials discussed may be categorized as follows:

Contents: Conventional ceramics – Glasses – Advanced oxide ceramics – Advanced non-oxide materials (nitrides, carbides and borides) – Carbon-based materials.

Semester:	e. o. WS	Hours per Week:	2	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	2

12. Ceramic Materials II: Functional ceramics (Keramische Werkstoffe: Funktionskeramik)

Institute of Nonmetallic Inorganic Materials

The lecture deals with selected functional ceramic materials. A materials-science standpoint is predominantly taken, but the physical effects that form the basis of the specific applications are discussed as well.

Contents: Physical and chemical foundations: crystal and electronic structure, point defects, internal surfaces, and space charge regions – Preparative methods: deposition of thin and thick films, sintering – Dielectric and semiconducting materials: thin films for electronic applications; grain boundary controlled devices (varistors, PTCs) – Ferroelectric, pyroelectric and piezoelectric materials: sensors and actuators – Ferromagnetic materials: magnetically hard and magnetically soft ceramics – Oxide superconductors: introduction to superconductivity; crystal structure, materials preparation, critical temperature, critical current, pinning, applications.

Semester:	e. o. SS	Hours per Week:	2	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	2

13. Polymers I (Polymerwerkstoffe I)

Institute of Applied Macromolecular Chemistry

Contents: Thermodynamics of polymer solutions and polymer blends – Solubility parameters – Statistical thermodynamics – Phase equilibria – Solid state of polymers – Phase transitions – Morphology of polymers – Glassy state – Crystallization and melting of polymers – Mechanical properties of polymers – Time-temperature superposition – Rubber elasticity.

Semester:	WS	Hours per Week:	2	Examination:	oral
Type:	L	Prerequisites:	--	Credits:	2

14. Polymers II
(Polymerwerkstoffe II)

Institute of Applied Macromolecular Chemistry

Contents: Characteristics and thermodynamics of multiphase polymer systems – Transition phenomena – Control of morphologies – Synthesis and technology of multiphase polymers – High impact plastics – Thermoplastic elastomers (block and segmented copolymers) – Polymer blends and composites

Semester: SS	Hours per Week: 1	Examination: certificate
Type: L	Prerequisites: --	Credits: 1

15. Materials Analysis I
(Werkstoffanalytik I)

Institute of Physical Metallurgy, 2nd chair

Contents: Basics of diffraction – X-Ray Diffraction – Light Microscopy – Quantitative Metallography – Scanning Electron Microscopy – Atomic Force Microscopy – Transmission Electron Microscopy.

Semester: e. o. WS	Hours per Week: 2+1	Examination: written
Type: L+E	Prerequisites: --	Credits: 4

16. Materials Analysis II
(Werkstoffanalytik II)

Institute of Physical Metallurgy, 2nd chair

Contents: Surface analysis – Vacuum physics – Surface structures – Imaging and diffraction methods – Chemical composition of surfaces – Analytical electron microscopy – Neutron diffraction.

Semester: e. o. WS	Hours per Week: 2+1	Examination: written
Type: L+E	Prerequisites: --	Credits: 4

17. Physical Chemistry III
(Physikalische Chemie III)

Institute of Physical Chemistry

Contents: Statistical thermodynamics and phenomena of transport – Molecular theory of chemical reactions.

Semester: SS	Hours per Week: 3	Examination: certificate*
Type: L	Prerequisites: Physical Chemistry I and II (Thermodynamics, Basics of quantum mechanics)	Credits: 3

*An oral examination on both lectures “Physical Chemistry III” and “Physical Chemistry of Solids” (see lecture no. 18) is possible on request.

18. Physical Chemistry of Solids
(Physikalische Chemie der Festkörper)

Institute of Physical Chemistry

Contents: Properties of interfaces – Dielectric properties – Corrosion and corrosion protection – Electrochemistry of solids – Introduction to selected experimental methods – Selected topics of current interest: nanomaterials, SAM's, sensors, fuel cells.

Semester: SS	Hours per Week: 3+2	Examination: certificate*
Type: L+E	Prerequisites: Physical Chemistry I and II (Thermodynamics, Basics of quantum mechanics)	Credits: 7

*An oral examination on both lectures “Physical Chemistry III” and “Physical Chemistry of Solids” (see lecture no. 17) is possible on request.

19. Technology of Forming I
(Umformtechnik I)

Institute of Technology of Forming

Contents: Basics of metal forming technology – Materials and materials physics – Mathematical description of forming – Tribology and wear – Basics of sheet metal forming – Stretch metal forming – Hydroforming – Deep drawing – Bending – Deep drawing of automotive parts.

Semester: WS	Hours per Week: 2	Examination: certificate
Type: L	Prerequisites: --	Credits: 2

20. Technology of Forming II
(Umformtechnik II)

Institute of Technology of Forming

Contents: Basics of bulk metal forming – Hot and cold flow forming – Rolling – Wire drawing – Tube and pipe drawing – Press forming – Upsetting – Cutting.

Semester:	SS	Hours per Week:	2	Examination:	certificate
Type:	L	Prerequisites:	--	Credits:	2

21. Elective Course
(Wahlpflichtfach)

The curriculum for students of materials science contains an elective course. This course is mandatory for admission to the final diploma examination but may be chosen from the following subjects: inorganic chemistry, technical chemistry, chemical engineering, solid state physics, solid state electronics, mineralogy, strength of materials, product engineering, laser technology, polymer science. Other subjects must be accepted by the examination board.
Type, hours per week and examination of the courses might differ.

Semester:	--	Hours per Week:	--	Examination:	--
Type:	--	Prerequisites:	--	Credits:	8

22. Colloquium on Current Topics in Materials Science
(Werkstoffwissenschaftliches Kolloquium)

The colloquium on current topics in Materials Science is a regular series of seminars at the Max-Planck-Institut für Metallforschung. In these seminars leading experts from all over the world give lectures on their current research topics. The lectures are given in English.

Semester:	--	Hours per Week:	--	Examination:	certificate*
Type:	L	Prerequisites:	--	Credits:	1

* To obtain the certificate one must attend 15 seminars.

3.2. Seminars

1. Seminar I: Physical Metallurgy
(Seminar I: Werkstoffphysik)

Institute of Physical Metallurgy, 2nd chair

Every student has to prepare a seminar talk on a given subject and attend the talks of the other participants. The topics of this seminar vary from year to year.

Semester:	SS	Hours per Week:	2	Examination:	certificate
Type:	S	Prerequisites:	--	Credits:	3

2. Seminar II: Metals
(Seminar II: Metalle)

Institute of Physical Metallurgy, 1st chair

This seminar serves to teach the students to read publications on a special topic of materials science, and to present this topic in a lecture. The topics may change from year to year and range from the basics of materials science to the newest findings in research.

Semester:	WS	Hours per Week:	2	Examination:	certificate
Type:	S	Prerequisites:	--	Credits:	3

3. Seminar III: Ceramics
(Seminar III: Keramik)

Institute of Nonmetallic Inorganic Materials

Selected scientific publications on ceramic science and technology are reviewed by the participants; a written summary is produced and the topic is presented to the class in form of a short lecture.

Semester:	SS	Hours per Week:	2	Examination:	certificate
Type:	S	Prerequisites:	--	Credits:	3

3.3. Laboratory Courses

1. Physical Metallurgy (Werkstoffphysik)

Institute of Physical Metallurgy, 2nd chair

Experiments: Transmission electron microscopy – Finite element method – Mechanical properties of thin films – Creep and fatigue – Superplasticity – Dynamical measurement of elastic constants – Fracture toughness (subject to change).

Semester:	SS	Hours per Week:	8	Examination:	oral
Type:	P	Prerequisites:	--	Credits:	10

2. Metals (Metalle)

Institute of Physical Metallurgy, 1st chair

Experiments: Metallography – Calorimetry – Diffusion – Corrosion – Determination of solution limits in binary alloys – Determination of thermodynamic activities – Discontinuous precipitation.

Semester:	WS	Hours per Week:	8	Examination:	certificate
Type:	P	Prerequisites:	--	Credits:	10

3. Ceramics (Keramik)

Institute of Nonmetallic Inorganic Materials

Experiments: Powder processing and powder characterization – Forming methods and greenbody characterization – Sintering and characterization of sintered bodies – Phase transformations and microstructure analysis – Ionic conductivity – Mechanical properties.

Semester:	WS	Hours per Week:	8	Examination:	oral
Type:	P	Prerequisites:	--	Credits:	10

4. Polymers
(Polymere)

Institute of Fibre and Textile Chemistry and
Institute of Applied Macromolecular Chemistry

Contents: Polymer Synthesis (Radical, Ionic, Coordinative Polymerization, Polyaddition, Polycondensation) – Manufacture of Fibers – Polymer Analysis (Size-Exclusion-Chromatography, Viscosimetry, Static Light Scattering, Ultracentrifugation) – Polymer Properties in the Solid State (Entropy Elasticity, Rheology, Thermal and Mechanical Properties, Crystallinity, Molecular Orientation) – Composites – Liquid Crystals.

Semester:	SS	Hours per Week:	8	Examination:	oral
Type:	P	Prerequisites:	--	Credits:	10

3.4. Final Thesis

The academic education in the course of studies "Materials Science" is completed after the final thesis, the so-called diploma thesis (Diplomarbeit), has been finished. This diploma thesis has to be done after the final oral examinations and covers a scope of maximum 6 months. In that time the student has to work on a scientific question on materials science, and has to write a thesis on this subject. During the diploma thesis the student is supervised by academic staff.

Semester:	--	Hours per Week:	--	Examination:	--
Type:	--	Prerequisites:	--	Credits:	30