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Curriculum for the

Master's Programme in Functional Materials Science

at the Faculty for Chemistry and Pharmacy at the University of Innsbruck

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§ 1 Allocation of the study programme

According to §54 para. 1 Universities Act 2002 – UA, the Master’s Programme in Functional Materials Science is grouped among the natural science study programmes.

§ 2 Admission

(1) Admission to the Master's Programme in Functional Materials Science requires completion of a relevant Bachelor's degree or a relevant Bachelor's degree from a university of applied sciences or another equivalent degree from a recognised domestic or foreign post-secondary educational institution.

(2) In any case, the following degrees are considered relevant: Bachelor's degree in Civil and Environmental Engineering, Chemistry, Secondary School Teacher Training in Chemistry, Physics, Secondary School Teacher Training in Physics, Pharmacy, Earth Sciences, Geo- and Atmospheric Sciences or Mechatronics at the University of Innsbruck. The Rectorate shall decide on the existence of another relevant degree programme in accordance with §64 para. 3 of the University Act.

(3) In order to compensate for significant differences in subject matter, supplementary examinations covering a maximum of 30 ECTS-Credits may be required, which must be taken by the end of the second semester of the master's programme.

§ 3 Qualification profile

(1) Subject-specific qualifications:
The graduates of the Master’s Programme in Materials and Nanoscience

- have in-depth theoretical and experimental knowledge of materials science with a particular focus on functional and nanostructured materials. They are proficient in handling complex material systems and have a thorough understanding of fundamental physical and chemical relationships.
- are able to comprehensively analyse chemical and physical material properties (e.g. mechanical, magnetic, electrical, optical) and select and apply suitable methods for synthesis, processing and characterisation. In doing so, they make targeted use of modern simulation and evaluation tools.
- are proficient in modern analytical techniques such as scanning electron microscopy, X-ray diffractometry, Raman spectroscopy and complementary methods for surface, phase and structural characterisation. They are able to critically evaluate and interpret complex experimental data.
- combine theoretical models with practical research, identify relevant materials science issues and are able to address these independently and at a high scientific level. The focus is on an interdisciplinary approach.
- specialise in relevant fields of application such as surface analysis, nano- and solid-state physics, biomedical materials or energy-related functionalities and can tailor their profile to their individual career goals.

(2) General qualifications: The graduates

- demonstrate strong scientific communication skills (e.g. in reports, publications, presentations) and are experienced in working with scientific literature and presenting research results to specialist audiences.
- work in a solution-oriented manner, analyse complex interrelationships with scientific rigour and are able to reflect on research in an ethical, social and ecological context. This includes, in particular, questions concerning the environmental and health impacts of new materials.
- are team players, have interdisciplinary networks and can plan, implement and successfully complete projects independently. They have skills in project and time management as well as in coordinating work in collaborative research teams.
- are capable of working in international and intercultural research environments and have an in-depth understanding of the dynamics of global scientific developments.

(3) Professional qualifications:

Graduates of the Master's Programme in Functional Materials Science

- are qualified for positions in industrial and academic research and development, particularly in the fields of materials testing, quality assurance, materials design, process optimisation and technical consulting.
- are able to apply their expertise in materials science in a wide range of industries (e.g. chemistry, semiconductor technology, energy technology, biomedicine, optics, aerospace) in a practical manner, integrating technical, economic and sustainability-related aspects.
- have skills that make them sought-after specialists in laboratories, testing institutes, development departments and innovation-driven companies – for example, in the development of new manufacturing processes, materials testing or technology transfer.

(4) The study programme qualifies students to independently conduct and manage research projects and to pursue further academic qualifications, such as a doctoral degree in materials science or related disciplines.

§ 4 Scope and duration

The Master’s Programme in Functional Materials Science covers 120 ECTS-Credits. This corresponds to a duration of four semesters. One ECTS-Credits corresponds to a workload of 25 hours.

§ 5 Language

The Master’s Programme in Functional Materials Science is offered in English.

§ 6 Types of courses and maximum number of students per course

(1) Courses without continuous performance assessment:

Lectures (VO) are courses held in lecture format. They introduce the research areas, methods and schools of thought for a given subject. Maximum number of participants: no maximum number of participants.

(2) Courses with continuous performance assessment:

1. Practical courses (PR) provide practical experience with concrete scientific tasks, complementing occupational and academic training. Maximum number of participants: 10
2. Introductory seminars (PS) introduce students interactively to scientific literature through the treatment of selected issues. They convey knowledge and methods of academic work. Maximum number of participants: 60
3. Seminars (SE) provide in-depth treatment of scientific topics through students’ presentations and discussion thereof. Maximum number of students: 60
4. Tutorials (UE) focus on the practical treatment of specific tasks in a specialist area and on practicing specific skills. Maximum number of students per course: 20
5. Lectures-tutorials (VU) focus on the practical treatment of concrete scientific tasks that are discussed during the lecture parts of the course. Maximum number of participants: 60

§ 7 Allocation of places in courses with a limited number of participants

In courses with a limited number of participants, course places are allocated as follows:

1. Students for whom the study duration would be extended due to the postponement are to be given priority.
2. If the criterium in no. 1 do not suffice, first, students for whom this course is part of a compulsory module will be given priority, and second, students for whom this course is part of an elective module.
3. If the criteria in no. 1 and 2 do not suffice, the available places will be randomly allocated.

§ 8 Structure of the study programme

The Master’s Programme in Functional Materials Science is grouped into the following modules:

(1) Compulsory modules in the disciplines of Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physics, Materials Technology and Theoretical Materials Science (65 ECTS-Credits) as well as Compulsory Modules Preparation of the Master's Thesis (7.5 ECTS-Credits) and Master's Thesis Defence (2.5 ECTS-Credits).

Compulsory Module	h	ECTS-Credits
1. Compulsory Module: Introduction to Materials Science	5	10
2. Compulsory Module: Introduction to Materials Science and Nanotechnology Structural Materials	5	9
3. Compulsory Module: Phases and Phase Transitions	4	5
4. Compulsory Module: Structures of Crystalline Materials	5	7.5
5. Compulsory Module: Mechanical Properties	3	5
6. Compulsory Module: Microscopy of Micro- and Nanostructures	5	5
7. Compulsory Module: Electrochemistry and Corrosion	5	5
8. Compulsory Module: Spectroscopy and Group Theory	4	5
. Compulsory Module: Fundamentals and Technology of Solids, Polymer Materials	6	8.5
10. Compulsory Module: Computer-Aided Materials Science	4	5
11. Compulsory Module: Preparation of the Master’s Thesis		7.5
12. Compulsory Module: Master’s Thesis Defence (Defensio)		2.5

(2) Elective modules for specialisation in the disciplines of Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physics, Textile Chemistry and Textile Physics, Materials Technology and Theoretical Materials Science. Modules covering 20 ECTS-Credits are to be passed from these elective modules.

Elective Modules for Subject Specialisation	h	ECTS-Credits
1. Elective Module: Cluster and Nanoparticles	3	5
2. Elective Module: Thin-Film Photovoltaics	4	5
3. Elective Module: Material Analysis	4	5
4. Elective Module: High-Pressure Synthesis and Processes	4	5
5. Elective Module: High-Pressure Solid-State Chemistry	3	5
6. Elective Module: Composite Materials	4	5
7. Elective Module: Coupled Processes in Materials	4	5
8. Elective Module: Textile Materials	4	5
9. Elective Module: Modern Functional Materials	4	5
10. Elective Module: Functional Materials of the Future	5	7.5
11. Elective Module: Colour Agents – Additives	3	5
12. Elective Module: Theoretical Methods in Materials Science	4	5
13. Elective Module: Applied Mineralogy	4	5
14. Elective Module: Advanced Crystallography	4	5

15. Elective Module: Physical-Chemical Mineralogy	4	5
16. Elective Module: Nanostructures and Interfaces in Energy Management, Catalysis and Electrochemistry	5	5
17. Elective Module: Interface and Material Analysis, Cryo-Physical Chemistry and Materials Science Seminar	-	5
18. Elective Module: Internship	-	5

(3) Elective **Module: General Skills**

Courses covering 5 ECTS-Credits are to be passed from this elective module.

Elective Module: General Skills	**h**	**ECTS-Credits**
Elective Module: General Skills	-	5

§ 9 Compulsory and elective modules

(1) Compulsory Modules:

1.	**Compulsory Module: Introduction to Materials Science**	**h**	**ECTS-Credits**
a.	**VU Physics for Materials Science** Physical concepts and laws with a focus on their application in materials science; calculations in the fields of mechanics, electrostatics, electrodynamics, optics, quantum mechanical model systems (harmonic oscillator, particle in a box), atomic physics, molecular physics, solid state physics.	2	4
b.	**VU Chemistry for Materials Science** Chemical laws and relationships with regard to materials science; structure of materials and the resulting properties; structural adjustments through different synthesis processes; introduction to electrical, thermal, magnetic and optical properties with a focus on ceramics, metals, glasses and polymers.	1	2
c.	**VU Mineralogy and Crystallography for Materials Science** Concepts of crystallography: long-range order, unit cell, Bravais lattice, point group and space group symmetry, and fundamentals of X-ray diffraction. Classification of minerals; most important and common minerals.	1	2
d.	**VU Basics of Materials Technology** Material properties and characterisation methods (mechanical, thermal, electrical, magnetic); composition and microstructure of materials and their influence on effective material properties. Introduction to important metallic, ceramic, polymer, semiconductor and composite materials; systematics of material selection;	1	2
	Total	**5**	**10**
	Learning Outcomes: The students are able to ad a.: apply physical concepts and laws from mechanics, electrostatics, electrodynamics, optics and solid-state physics in the context of materials science issues, analyse quantum mechanical model systems such as the harmonic oscillator and the particle in a box, and explain their significance for atomic, molecular and solid state physics.		

	ad b.: explain chemical principles relating to the structure and properties of materials, evaluate structural adjustments made using different synthesis processes, and analyse and compare the electrical, thermal, magnetic and optical properties of materials such as ceramics, metals, glass and polymers. ad c.: describe crystallographic concepts such as long-range order, unit cells, Bravais lattices, point and space group symmetry, and systematically apply them to the classification and analysis of the most important mineral classes, taking into account the fundamentals of X-ray diffraction. ad d.: examine material properties using mechanical, thermal, electrical and magnetic characterisation methods, evaluate the composition and microstructure of materials in terms of their effect on functional properties, and justify the systematic selection of metallic, ceramic, polymeric, semiconducting and composite materials in a differentiated manner.
	Prerequisites: none

2.	**Compulsory Module: Introduction to Materials Science and Nanotechnology Structural Materials**	**h**	**ECTS-Credits**
a.	**VO Materials Science Mineralogy** Material classes and manufacturing processes in the building materials, glass and ceramics industries; non-hydraulic binders.	3	6
b.	**VO Solid-State Chemistry II** Inorganic functional materials relevant to materials science: structure-property relationships in various substance classes (hard materials and highly efficient inorganic phosphors for high-performance applications), their synthesis, and technically relevant electronic, optical, and magnetic properties.	2	3
	Total	**5**	**9**
	Learning Outcomes: The students are able to ad a.: understand practical relationships between chemical composition, crystal structure and physical properties of important products in technical mineralogy and will be familiar with the processes involved in their manufacture. ad b.: apply knowledge and understanding of materials science-relevant inorganic functional materials and their structure-property relationships, including hard materials, highly efficient inorganic phosphors, and technically relevant electronic, optical, and magnetic properties; draw critical assessments and conclusions regarding the structure-property relationships of various substance classes in inorganic chemistry, including technically relevant materials, inorganic luminescent materials and their applications in high-performance applications.		
	Prerequisites: none		

3.	**Compulsory Module: Phase and Phase Transitions**	**h**	**ECTS-Credits**
a.	**VO Phase Transitions** Thermodynamic description and classification of phase transitions, order parameters, critical phenomena, nucleation and growth, surface melting, glass transition, experimental methods for observing phase transitions.	1	1.5
b.	**VU Phase Diagrams** Interpretation of phase diagrams from the areas of ceramics and metallurgy, principles of thermodynamics for calculating phase relations, thermodynamic mixing models for solid materials.	1	1.5

c.	**PR Experimental Studies of Phase Transitions** Determination of latent heat, heat capacity, expansion coefficients, compressibility, critical phenomena, solid-solid transitions, determination of glass transitions, cold crystallization and freezing concentration, P-V-T analyses of fluid inclusions, thermoanalytical methods, dilatometry, heating microscopy, calorimetry, high- and low-temperature diffraction, high-temperature diffraction and Raman spectroscopy, high-pressure diffraction and spectroscopy.	2	2
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: apply thermodynamic concepts to describe and classify phase transitions, analyse order parameters and critical phenomena, explain processes such as nucleation, growth and glass transition, and select and evaluate suitable experimental methods for observing these transitions. ad b.: interpret phase diagrams from ceramics and metallurgy, apply thermodynamic principles to calculate phase relationships, and explain thermodynamic mixture models for solids in a differentiated manner. ad c.: experimentally determine latent heat, heat capacities, expansion coefficients and compressibilities, analyse critical phenomena such as solid-liquid transitions, glass transitions and crystallisation processes using methods such as dilatometry, calorimetry, Raman and high-temperature diffraction, P-V-T analysis and spectroscopy, and critically reflect on their suitability for investigating complex phase transitions.		
	Prerequisites: none		

4.	**Compulsory Module: Structures of Crystalline Materials**	**h**	**ECTS-Credits**
a.	**VO Crystallographic Diffraction Methods** Theory of structure determination of materials by diffracting rays: x-rays, synchrotron radiation, neutrons, electrons, powder diffraction; use of crystallographic databases.	3	6
b.	**PR Diffraction Methods** Methods of single crystal X-ray structural analysis and powder diffractometry through practical work; computer-assisted evaluation and interpretation of measurement results; data visualisation.	2	1.5
	Total	**5**	**7.5**
	Learning Outcomes: ad a. und b.: Students are familiar with the theoretical principles of diffraction methods for determining the structure of materials and can apply these in practice. .		
	Prerequisites: none		

5.	**Compulsory Module: Mechanical Properties**	**h**	**ECTS-Credits**
a.	**VU Mechanics of Materials** Fundamentals of materials mechanics (stress/strain tensor, constitutive laws); modelling of elastic, time-dependent and inelastic behaviour (plastic/damage behaviour) and their relationship to processes and observations on finer (atomic/molecular) length scales.	2	3

b.	**PR Characterisation of Mechanical Material Properties** Methods of displacement/force measurement; mechanical (destructive and non-destructive) testing methods, including static, cyclic and dynamic loading; interpretation of test results and statistical analysis; determination of material parameters from test data describing the elastic, time-dependent and inelastic behaviour (plastic/damage behaviour) of materials.	1	2
	Total	**3**	**5**
	Learning Outcomes: The students are able to ad a.: explain basic concepts of materials mechanics, including stress and strain tensors and constitutive laws for modelling elastic, time-dependent and inelastic material behaviour, and link these to processes at the atomic and molecular scale. ad b.: experimentally apply mechanical testing methods to characterise the elastic, plastic and damage-relevant behaviour of materials under static, cyclic and dynamic loading, determine material parameters from test data and interpret the results in a differentiated manner using statistical methods.		
	Prerequisites: none		

6.	**Compulsory Module: Microscopy of Micro- and Nanostructures**	**h**	**ECTS-Credits**
a.	**VO Scanning Probe and Electron Microscopy** Principles and operation principles of scanning probe microscopy, atomic force microscopy, surface-potential microscopy, electric-force-microscopy, friction microscopy and transmission electron microscopy.	1	1.5
b.	**PR Scanning Probe and Electron Microscopy** Characterisation of surfaces on the nanoscale and with atomic resolution by using scanning-probe methods, investigation of nano particles and layered materials with transmission electron microscopy.	2	1
c.	**VU Optical Properties of Solids** Theory of the refraction index, spindle stage examination and direction-dependence of the refraction index of single crystals, relationship of the refraction index with electronic and ionic polarisation as well as its de-pendency on frequency; colours of solids.	1	1,5
d.	**PR Optical Microscopy** Fundamentals of optical polarisation microscopy, indicatrix, optical behaviour of isotropic media as well as uniaxial and biaxial crystals.	1	1
	Total	**5**	**5**
	Learning Outcomes: The students are able to: ad a.: understand and describe the fundamentals and applications of scanning probe microscopy, atomic force microscopy and other microscopic techniques, including surface potential microscopy, electric force microscopy, friction microscopy and transmission electron microscopy. ad b.: characterise surfaces at the nanoscopic level and with atomic resolution, including the use of scanning probe methods, and conduct investigations of nanoparticles and layered materials using electron microscopy. ad c.: analyse the optical properties of solids using refractive index theory, apply various contrast techniques such as phase contrast, interference contrast and dark field microscopy, and explain differences in colour behaviour and directional dependence of optical phenomena.		

	ad d.: apply the fundamentals of polarisation microscopy to isotropic and anisotropic media, distinguish between the optical uniaxial and biaxial characteristics of crystals, and represent them using the indicatrix.
	Prerequisites: none

7.	**Compulsory Module: Electrochemistry and Corrosion**	**h**	**ECTS-Credits**
a.	**VU Electrochemistry** Electrochemical fundamentals (potentials and currents, structures at phase interfaces, conductivity & interactions in ion systems), electrochemical examination methods, fundamentals of passivity and corrosion: thermodynamics (Pourbaix diagrams), electrode kinetics.	2	2
b.	**VO Corrosion** Phenomenology of corrosion processes, analysis of atomic and molecular processes on corroding interfaces, corrosion protection, mechanisms of high-temperature corrosion.	1	1
c.	**PR Electrochemistry Applications** E.g. fuel cells, corrosion measuring cell, impedance spectroscopy, electrochemical and microscopic characterisation of uniform and localised corrosion phenomena, growth of oxide layers, chemical and electronic properties of complex oxide electrolytes.	2	2
	Total	**5**	**5**
	Learning Outcomes: The students are able to ad a.: analyse electrochemical fundamentals such as potentials, currents, electrochemical double layers, conductivity, phase boundaries and interactions in ionic systems, explain electrochemical investigation methods and the concepts of passivity and electrode kinetics, and apply Pourbaix diagrams to describe corrosion thermodynamics. ad b.: corrosion processes at the atomic and molecular level, evaluate corrosive interfaces from a thermodynamic and kinetic perspective, justify protection strategies and explain the mechanisms of high-temperature corrosion in a differentiated manner. ad c.: experimentally apply electrochemical and microscopic methods for characterising oxide layers and corrosion phenomena, perform impedance spectroscopy as well as corrosion and fuel cell measurements, and interpret the chemical and electronic properties of complex oxide electrolytes with regard to their function.		
	Prerequisites: none		

8.	**Compulsory Module: Spectroscopy and Group Theory**	**h**	**ECTS-Credits**
a.	**VU Group Theory** Concepts of group theory, representation theory, character tables, symmetry groups: point groups, space groups, symmetry breaking, projection operator methods and applications in optical and vibrational spectroscopy, electronic structure and phase transitions.	2	3
b.	**VU Introduction to Spectroscopy** Wave and particle nature of matter and light, structure of matter, atomic spectra, interaction of matter with electromagnetic radiation, rotational, vibrational and rotational-vibrational excitation of molecules, electronic excitation of molecules, spectroscopy of solids.	2	2
	Total	**4**	**5**

	Learning Outcomes: The students are able to ad a.: apply concepts of group theory, including representation theory, character tables, symmetry groups, point and space groups, symmetry breaking and projection operator methods, to optical, electronic and vibrational spectroscopic phenomena, as well as to phase transitions and electronic structure, and analyse their significance for material characterisation. ad b.: explain the interaction of electromagnetic radiation with matter, taking into account wave and particle nature, the structure of matter and atomic spectra, interpret rotational, vibrational and rotational-vibrational spectra as well as electronic transitions in molecules and solids, and use spectroscopic methods specifically for material-specific analysis.
	Prerequisites: none

9.	Compulsory Module: Fundamentals and Technology of Solids, Polymer Materials	h	ECTS-Credits
a	**VU Solid-State Materials Technology** Structure, lattice vibrations, electronic properties, transport properties. Metals, insulators, semiconductors, magnetism, correlation phenomena .	2	3
b.	**PR Transport Properties** Determination of important material parameters for charge, heat or material transport in solids, e.g. electrical conductivity, thermal conductivity, Hall conductivity, mobility, charge carrier concentration, excitation energy, band gap.	1	1
c.	**VO Amorphous Materials in Nature and Technology** Amorphous materials in nature and technology (oxide glasses, amorphous polymers, organic glasses, (semi-)metallic glasses, amorphous ice); material properties and areas of application; production of amorphous materials; structural models of amorphous materials, differentiation from crystals and nanocrystals; phase transitions, in particular the glass transition of amorphous materials; phase change technology; historical and modern glass production and processing; technical glass (safety glass, heat protection glass, light protection glass, smart glass, glass fibres, etc.).	1	2
d.	**VO Polymer Chemistry** Structure of polymeric materials, polymer reactivity, physical and chemical data of polymeric materials, technical properties, technical polymers as materials, composite materials and lightweight materials, technical textiles, functional polymers. Integrated aspects: LCA, recycling, disposal.	1	1.5
e.	**VO Polymer Analysis** Thermal analysis (DSC, TG), sorption methods, determination of porosity, crystallinity, spectroscopic methods (IR, NMR, MS), molecular weight distribution, end group determination, microscopy.	1	1
	Total	**6**	**8.5**
	Learning Outcomes: The students are able to ad a.: explain the structure, lattice vibrations, electronic properties and transport phenomena of metals, insulators and semiconductors, taking into account magnetism and correlation effects, and apply this knowledge to technological issues in solid state materials technology. ad b.: perform experimental methods to determine material properties such as electrical conductivity, thermal conductivity, Hall conductivity, mobility, charge carrier concentration, excitation energy and band gap, and evaluate their significance for charge, heat and material transport in solids.		

	ad c.: analyse the structure and properties of amorphous materials such as glasses, polymers and metallic glasses, describe their production, phase transitions and differentiation from crystalline phases, and systematically present historical and modern applications, including technical glasses, glass processing and functional special glasses. ad d.: analyse the structure of polymeric materials and their physical and chemical properties, including polymer reactivity, technical application properties and ecological aspects such as LCA, recycling and disposal, and systematically evaluate technical polymers as materials, composite and lightweight materials, and functional polymers in the context of current applications. ad e.: apply analytical methods such as thermal analysis, sorption methods, porosity and crystallinity determination, IR, NMR and mass spectrometry, end group determination, molecular weight distributions and microscopy to polymeric materials and evaluate their suitability for structural and functional characterisation in a well-founded manner.
	Prerequisites: none

10.	Compulsory Module: Computer-Aided Materials Science	h	ECTS-Credits
a.	**VO Introduction to Computer-Assisted Materials Science** Polarizability and multi-body effects, reactive force fields, periodic approaches in quantum mechanics, density functional theory, application examples.	2	2.5
b.	**PR Numerical Methods – Computer Operations for Determining Physical-Chemical Properties** Use of various codes for numerical calculation of material properties.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to: ad a.: explain the fundamentals of computer-aided modelling in materials science, including polarizability, multi-body effects, reactive force fields, periodic quantum systems and density functional theory, and critically reflect on these concepts using appropriate application examples. ad b.: apply various numerical codes for calculating physical and chemical material properties in practice, evaluate their suitability for describing complex material systems, and interpret results in a methodologically sound manner with regard to accuracy and significance.		
	Prerequisites: none		

11.	Compulsory Module: Preparation of the Master's Thesis	h	ECTS-Credits
	Agreement on the topic, the scope and the form of the Master's Thesis on the basis of a brief summary of the contents (synopsis) as well as agreement on the work processes and the study progress. Planning of an appropriate time frame for the completion of the Master's Thesis.	-	7.5
	Total	**-**	**7.5**
	Learning Outcomes: Students are able to write a brief description of the content of their planned Master's Thesis (synopsis), correctly applying the conventions of the subject area with regard to presentation, stylistic devices, structure and content, using high-quality, credible and relevant sources to present their ideas, presenting the core concept of the planned Master's Thesis, define the scope and outline a timeline, apply the principles of good scientific practice, draft a detailed laboratory work plan that includes the specific methods and techniques required to carry out		

	their Master's Thesis, taking into account relevant safety protocols and ethical guidelines to ensure that all experimental work complies with good laboratory practice standards.
	Prerequisites: none

12.	**Compulsory Module: Master's Thesis Defence (Defensio)**	**h**	**ECTS-Credits**
	Presentation and final oral defence (Defensio) of the independently written Master's Thesis as part of an academic lecture, followed by an academic discussion and questioning by an examination board.		2.5
	Total		**2.5**
	Learning Outcomes: Students are able to link their highly specialised knowledge, at least in the area of their Master's Thesis, to the latest scientific findings, to refer to information and analyses that support their own results to an appropriate extent, and to explain the methodological basis and central findings of their Master's Thesis in a comprehensible manner and communicate them convincingly.		
	Prerequisites: positive evaluation of all modules and the Master's Thesis		

(2) Elective modules "Specialisation":

Elective modules covering 20 ECTS-Credits are to be selected and passed:

1.	**Elective Module: Cluster and Nanoparticles**	**h**	**ECTS-Credits**
	VU Special Topics 1: Cluster and Nano Physics Introduction to cluster physics, production and characteristics of clusters, free and deposited clusters and nano particles.	3	5
	Total	**3**	**5**
	Learning Outcomes: Students are able to explain and classify the physical fundamentals, manufacturing methods and properties of clusters and nanoparticles, and can reflect scientifically on current issues in nano- and cluster physics.		
	Prerequisites: none		

2.	**Elective Module: Thin-Film Photovoltaics**	**h**	**ECTS-Credits**
a.	**VU Thin-Film Photovoltaics** Introduction to thin-film photovoltaics: fundamentals of photovoltaics, available solar radiation, comparison of different photovoltaic technologies, deposition processes in thin-film photovoltaics, from solar cell to solar module, roll-to-roll manufacturing of flexible photovoltaics.	2	2.5
b.	**PR Deposition and Analysis of Thin Films** Based on current research, modern materials are used to deposit thin layers using plasma-based PVD processes; the layers formed are analysed using individual analysis methods specialised in thin layers (1 nm to 3 µm); main topics: TCOs (transparent conductive oxides), novel metal electrodes (platinum) on flexible substrates, absorber layers for photovoltaics.	2	2.5
	Total	**4**	**5**

	Learning Outcomes: The students are able to: ad a.: explain the fundamentals of thin-film photovoltaics, including available solar radiation, various photovoltaic technologies and suitable deposition processes, understand the process chain from solar cell to solar module, and critically assess the role of roll-to-roll manufacturing of flexible systems for photovoltaics. ad b.: apply plasma physics deposition processes for the production of functional layers for photovoltaics in practice, characterise the layers formed using analytical methods in terms of structure and function, and evaluate the properties of transparent conductive oxides, metal contacts and absorber layers with regard to their suitability for flexible photovoltaic systems.
	Prerequisites: none

3.	**Elective Module: Material Analysis**	**h**	**ECTS-Credits**
a.	**VU IR-Spectroscopy** Theoretical fundamentals of IR spectroscopy; detailed knowledge of practical work with the device based on selected examples for qualitative and quantitative analysis of geologically relevant samples.	1	1.5
b.	**VU Raman-Spectroscopy** Theoretical fundamentals of Raman spectroscopy; detailed knowledge of practical work with the device based on selected examples for qualitative and quantitative analysis of geologically relevant samples.	1	1.5
c.	**VU Thermoanalysis** Theoretical fundamentals and measurement principles of thermoanalytical methods (differential thermal analysis, differential scanning calorimetry, thermogravimetry, thermomicroscopy); supplemented by practical measurements and data evaluations.	1	1
d.	**VU X-Ray Fluorescence Analysis** Theoretical fundamentals of X-ray fluorescence; practical aspects such as sample preparation, standardisation and correction procedures, and quantitative analysis using XRF and µXRF.	1	1
	Total	**4**	**5**
	Learning Outcomes: The students are able to: ad a: independently apply IR spectroscopy to geoscientific questions and interpret their results in a well-founded manner, recognise sources of error and limitations of this method, and critically evaluate and classify measurement results in the context of geoscientific processes. ad b.: independently apply Raman spectroscopy to geoscientific questions and interpret their results in a well-founded manner, recognise sources of error and limitations of this method, and critically evaluate and classify measurement results in the context of geoscientific processes. ad c: explain the theoretical principles and measurement principles of thermoanalytical methods, as well as carry out practical measurements, evaluate them and interpret them in a geoscientific context. ad d: explain the theoretical principles and practical applications of X-ray fluorescence analysis, prepare samples professionally, and independently perform and evaluate quantitative analyses using XRF and µXRF.		
	Prerequisites: none		

4.	Elective Module: High-Pressure Synthesis and Processes	h	ECTS-Credits
a.	**VO High Pressure Materials (Experimental Petrology)** Fundamentals of methods for generating high pressure and temperatures, determination of elastic properties, pressure-induced phase transitions, metastable materials, pressure dependence of chemical equilibrium and reactions kinetics, high pressure synthesis of new materials.	2	3
b.	**UE Materials Under High Pressure** Practical exercises with hydrothermal systems, piston-cylinder presses, multi-anvil presses, diamond stamp cells	2	2
	Total	**4**	**5**
	Learning Outcomes: Students are familiar with the functioning and limitations of various experimental synthesis methods and are able to independently plan and conduct high-pressure, high-temperature experiments.		
	Prerequisites: none		

5.	Elective Module: High-Pressure Solid State Chemistry	h	ECTS-Credits
a.	**VO Advanced Solid State Chemistry** Advanced study of Solid State Chemistry in special consideration of modern strategies of syntheses, such as high-temperature and high-pressure synthesis; insights into modern solid state characterisation methods and introduction to current research fields and applications in solid state chemistry.	1	2
b.	**PR Lab Practice: High-Pressure Solid State Chemistry** Experimental implementation of modern high-pressure synthesis (multi-anvil technique) with a focus on current issues in the synthesis of new functional materials.	2	3
	Total	**3**	**5**
	Learning Outcomes: The students are able to ad a.: apply knowledge and understanding of advanced concepts and theories in solid state chemistry, including modern synthesis strategies such as high-temperature and high-pressure synthesis, solid-state characterisation methods, and current research areas and applications; apply integrated knowledge and problem-solving skills in solid state chemistry, including the interpretation of experimental results, the analysis of functional materials, and the application of solid-state characterisation methods; ad b.: demonstrate critical judgement in the assessment and application of methods and techniques of high-pressure solid-state chemistry, including the multi-anvil technique, the synthesis of new functional materials and current issues; conduct independent experiments using modern high-pressure synthesis techniques, including planning, selecting appropriate synthesis parameters and safe laboratory practices; communicate results and findings from solid-state chemistry both orally and in writing in a clear and professional manner, including discussing research results, presenting syntheses, and interpreting data; act independently and ethically responsibly in scientific research and the application of solid-state chemistry, including consideration of safety regulations, ethical considerations, and scientific integrity.		
	Prerequisites: none		

6.	Elective Module: Composite Materials	h	ECTS-Credits
a.	**VU Porous Materials** Properties of porous materials, including their effective physical (mechanical, thermal, transport) and pore space properties; methods for model-based determination of effective physical properties (micromechanics, unit cells and representative volume elements); experimental characterisation of effective physical and pore space properties; pore space analysis based on 3D voxel images; industrial applications, such as foams, porous ceramics and biomaterials.	2	2.5
b.	**VU Fibre-Reinforced Composites** Classification and properties of composite materials, including bio- and nano-composites; modelling of effective mechanical properties (micromechanics, laminate theory, fibre-matrix interaction); test methods for the mechanical characterisation of components (matrix, fibres) and composite materials; industrial applications such as fibre-reinforced polymers, ceramic matrix composites and bio-based composites.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to: ad a.: analyse the physical and structural properties of porous materials, including mechanical, thermal and transport phenomena, apply micromechanical modelling methods to determine effective material properties, interpret experimental characterisation methods based on 3D voxel images, and evaluate industrial applications of porous ceramics, foams and biomaterials in a differentiated manner. ad b.: analyse composite materials, including bio-, nano- and fibre composite systems, in terms of their structure, properties and mechanical behaviour using micromechanical and laminate theory models, apply test arrangements for characterising matrix and fibre components, and systematically assess the possible applications of polymer, ceramic and bio-based composite materials.		
	Prerequisites: none		

7.	Elective Module: Coupled Processes in Materials	h	ECTS-Credits
a.	**VO Coupled Processes in Materials** Physical/chemical processes in materials in an industrial context (production/use/disposal); modelling of chemical reactions, mechanical behaviour and transport processes (thermal, diffusion, fluid transport), including the coupling of these phenomena; methods for simulating and analysing coupled problems.	2	2.5
b.	**UE Coupled Processes in Materials** Illustration of the basic principles of numerical methods using simplified 1D examples; introduction to and evaluation of available commercial software; modelling and simulation of coupled processes in the context of industrial applications.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: analyse physical-chemical processes in materials in an industrial context, describe chemical reactions, mechanical behaviour and transport phenomena such as thermal, diffusion		

	and fluid transport using models, understand their interrelationships in theoretical terms and critically evaluate suitable simulation methods for analysing coupled systems. ad b.: apply basic principles of numerical methods using simplified 1D examples, assess available commercial simulation software in terms of its suitability for coupled problems, and model and analyse coupled processes in materials in industrial applications in a targeted manner.
	Prerequisites: none

8.	**Elective Module: Textile Materials**	**h**	**ECTS-Credits**
a.	**VO Chemistry of Textile Materials** Chemistry of natural and synthetic polymers for the production of textile fibres, surface finishing, structure and physiological qualities of textile fibres, chemical modification and functionalisation, basic terms of textile materials and production techniques.	2	2.5
b.	**VO Technical Textiles and Composites** Chemical fundamentals and processes for the manufacture and processing of composite materials, technical textiles: materials for medical applications, filter materials, construction technology, plastics technology, lightweight vehicle construction, aerospace, conveyor technology and transport (materials, requirements, technical design).	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: analyse natural and synthetic polymers in terms of their suitability for textile fibre production, assess the structural and surface properties as well as the physiological properties of textile fibres, apply chemical modification and functionalisation processes, and correctly classify the basic production techniques and material classes of textile chemistry. ad b.: explain the chemical principles and processes involved in the manufacture of technical textiles and composites, evaluate material systems for applications in medicine, construction, aerospace, automotive engineering and conveyor technology in terms of properties, requirements and technical implementation, and justify the specific selection of suitable materials for each application scenario.		
	Prerequisites: none		

9.	**Elective Module: Modern Functional Materials**	**h**	**ECTS-Credits**
a.	**VO Advanced Functional Textiles** 3D fibre assembly technologies, preforms, carbon fibres, dynamic wetting, fibre-liquid interfaces, textile-based electrodes for electrochemical energy storage, functional textile coatings, coating technologies, adhesion mechanisms, conductive textiles, textile-based sensors.	2	2.5
b.	**VO Fibre Sustainability and Recycling** Approaches to improving sustainability in the manufacture, modification and processing of fibre materials and textile substrates, as well as developments in fibre-to-fibre recycling for sorting textile waste, isolating individual polymer types and reusing them in the manufacture of new substrates.	2	2.5
	Total	**4**	**5**

	Learning Outcomes: The students are able to ad a.: explain advanced technologies for fibre and textile functionalisation, such as 3D fibre assembly, carbon fibres, dynamic wetting, fibre interfaces, coating processes and textile-based electrodes for energy storage and sensor technology, analyse their operating principles and critically evaluate the functionality of textile-based systems in terms of conductivity, adhesion and potential applications. ad b.: explain approaches to improving sustainability in the manufacture, modification and reuse of textile fibres, including fibre-to-fibre recycling, polymer insulation and substrate development, and systematically assess their relevance for sustainable material cycles in textile technology.
	Prerequisites: none

10.	**Elective Module: Functional Materials of the Future**	**h**	**ECTS-Credits**
a.	**VO Advanced Materials for Energy Conversion and Storage** Fundamentals of energy conversion and energy storage; techniques and systems for energy transport; applications and challenges in energy storage; innovative materials for high-performance batteries; properties and development of modern functional materials; structure and mechanisms of primary batteries (non-rechargeable); structure and function of secondary batteries (rechargeable); key concepts in battery research; methods for characterising and analysing battery performance; principles of performance measurement and evaluation; specific characteristics of lithium-ion batteries; research into alternatives and beyond lithium-ion technologies; various concepts and approaches for fuel cells and electrolysis cells, from high-temperature to electrochemical devices, with a focus on current materials for the energy transition; principles of photovoltaics; material requirements and manufacturing processes; overview of thin-film technologies; comparison between flexible and rigid technologies.	3	4.5
b.	**VO Responsive Functional Materials** Introduction to responsive functional materials; characterisation using diffractometric and spectroscopic methods; properties and applications of hybrid materials consisting of porous host lattices and chromophore molecules; fundamentals of photochemistry	2	3
	Total	**5**	**7.5**
	Learning Outcomes: The students are able to ad a.: explain the fundamentals of energy conversion and energy storage, analyse energy transport systems and the challenges of modern storage technologies, evaluate functional materials for high-performance primary and secondary batteries, including Li-ion systems and their alternatives, in terms of structure, mechanism of action, performance characteristics and research prospects, present key concepts of electrochemical and photovoltaic technologies, compare thin-film processes and material requirements for flexible and rigid systems, and systematically classify current developments in electrochemical devices, fuel cells and electrolysis cells. ad b.: generate in-depth knowledge of responsive functional materials and describe and apply their characterisation using specific methods, including diffractometric and spectroscopic methods, hybrid materials with porous host lattices and chromophore molecules, and the fundamentals of photochemistry, reflect on an in-depth understanding of the properties and applications of hybrid materials, including their composition, structure, and their response to external stimuli; critically analyse and interpret current scientific literature to gain a deeper		

	insight into the topics covered in the module, including the latest developments in solid state chemistry, homogeneous catalysis, and responsive functional materials.
	Prerequisites: none

11.	**Elective Module: Colouring Agents – Additives**	**h**	**ECTS-Credits**
a.	**VO Colour Agents, Pigments, Additives** Important polymer additives (colourants, pigments, emollients, light and aging protection, antimicrobial products, functional additives).	1	2
b.	**PR Textile Materials – Polymer Technology** Characterisation of textile materials: mechanical, thermal, optical, electrical and structural properties; physical, chemical and mechanical properties of textile fibres, surfaces and composites; colour coordinates, determining the concentrations aging tests, application simulation.	2	3
	Total	**3**	**5**
	Learning Outcomes: The students are able to ad a.: explain the chemical fundamentals of textile materials, including natural and synthetic polymers for fibre production, surface finishing, chemical modification and functionalisation, analyse the structure-property relationships of textile fibres, and systematically describe basic textile manufacturing processes. ad b.: explain the chemical and process engineering principles behind the manufacture of technical textiles and composite materials, evaluate requirements and design variants for applications in medicine, filtration, construction engineering, vehicle manufacturing, aerospace and conveyor technology, and justify the selection of suitable materials for specific applications.		
	Prerequisites: none		

12.	**Elective Module: Theoretical Methods in Materials Science**	**h**	**ECTS-Credits**
a.	**VO Electronic Structure of Materials** Electron structure theory of molecular materials and solid-state systems; Hartree-Fock and density functional theory; basis set types; periodic systems and Bloch's theorem; density functional tight-binding models; integration of electron structure theory with chemical simulation techniques (i.e. Monte Carlo and molecular dynamics).	2	3
b.	**PR Computer-Aided Evaluation of Material Properties** Computer-aided design of materials; introduction to the use of relevant programmes; quantum mechanical and force field-based calculations of solids and solid surfaces.	2	2
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: apply electron structure theories such as Hartree-Fock and density functional methods to molecular materials and periodic solid-state systems, explain basis set types and the Bloch theorem, differentiate between density functional bonding models, and critically evaluate their		

	integration with chemical simulation techniques such as Monte Carlo and molecular dynamics methods. ad b.: apply quantum mechanical and force field-based computer methods for calculating the electronic properties of solids and surfaces in practice, use programmes for material-specific simulation in a targeted manner, and evaluate the computer-aided design of materials in terms of applicability and significance.
	Prerequisites: none

13.	Elective Module: Applied Mineralogy	h	ECTS-Credits
a.	**VU Deposits of Metal Ores and Industrial Minerals** Occurrence, properties and formation of important metal ores and industrial minerals; aspects of raw material supply.	3	4
b.	**VU Metals and Alloys** Production, properties, nomenclature, use and recycling of metallic materials (e.g. steels, non-ferrous metals, high-tech alloys).	1	1
	Total	**4**	**5**
	Learning Outcomes: ad a. and b.: Students are familiar with the mineral raw materials and resources used in key industrial sectors and understand the fundamentals of natural formation processes, technical processing as materials, and recycling. Students can evaluate the criticality of primary and secondary raw material supply in the context of historical, current, and future resource management.		
	Prerequisites: none		

14.	Elective Module: Advanced Crystallography	h	ECTS-Credits
a.	**VU Methods of Powder Diffraction** Selected chapters on powder diffraction and diffraction analysis of polycrystalline materials in the field of materials science are presented. Examples include quantitative phase analysis of crystalline mixtures, determination of amorphous fractions, crystallite size determination, microstrain investigations to determine real parameters, *in-situ* diffraction measurements at laboratory and large-scale research facilities to describe temperature- and pressure-dependent reactions and their evaluation.	2	2.5
b.	**VU Selected Chapters of Structural Research** Introduction to the description and analysis of solids that have an aperiodic structure or a more or less severe disruption of long-range order. These include quasicrystals, modulated structures and compounds with severe disorder.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: Students are familiar with current trends in diffraction analysis of single-crystal and polycrystalline solids and are able to perform and evaluate practical analyses.		
	Prerequisites: none		

15.	Elective Module: Physical-Chemical Mineralogy	h	ECTS-Credits
a.	**VU Crystal Physics** The course aims at introducing to tensorial description of phenomena in crystal physics, which have a significant importance for numerous practical applications. Contents include thermal, dielectric, magnetic, elastic and optical properties of crystals.	2	2.5
b.	**VU Thermodynamic Modelling** Introduction to P-T determination of materials and metamorphous stones, fundamentals and types of reactions between solid phases, chemigraphy of solid-state body reactions; thermodynamic modelling of chemical systems of function of P, T and X (chemical composition). Phase diagrams and pseudo sections as function of P-T-X activity models of solid phases, experimental calibration of geothermal barometers. Internally consistent thermodynamic data records.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: ad a. and b.: Students will gain an overview of the physical and thermodynamic aspects of crystalline phases.		
	Prerequisites: none		

16.	Elective Module: Nanostructures and Interfaces in Energy Management, Catalysis and Electrochemistry	h	ECTS-Credits
a.	**VU Kinetics and Dynamics of Surface Processes** Mechanisms of molecular and dissociative adsorption. Kisliuk isotherm, potential energy surfaces, activated adsorption, atomic and molecular bonding to surfaces in the MO picture, band structure and density of states, catalysis, Vulcan relationship.	1	1
b.	**VU Energy Engineering and Catalysis** Electronic and structural principles of heterogeneous catalysis, physicochemical properties of nanostructured catalytic materials, environmental catalysis, exhaust gas purification, processes for chemical energy storage and conversion, CO2 storage and utilisation.	1	1
c.	**VU Electrochemistry and Applications in Energy Research** In-depth examination of investigation methods (e.g. rotating (ring) disc electrode, electrochemical impedance spectroscopy), semiconductor electrochemistry (e.g. Mott-Schottky evaluation), fundamentals of electrocatalysis and Li-ion insertion, and applications (e.g. in fuel cells or Li-ion batteries).	1	1
d.	**PR Current Research in Physical Chemistry** Work in current research in a physical chemistry working group chosen by the student, e.g. characterisation and structural investigation of surface and nanostructured adsorbate systems (LEED, STM, ARUPS), catalytic CO2 hydrogenation to energy carriers, reforming of energy carriers for hydrogen production, product analysis (MS, GC), catalytic characterisation of SOFC-relevant materials, electrocatalysis and battery research, photo-electrochemistry.	2	2
	Total	**5**	**5**

	Learning Outcomes: The students are able to ad a.: generate and apply in-depth knowledge of the mechanisms of surface processes, including mechanisms of molecular and dissociative adsorption, Kisliuk isotherms and potential energy surfaces. ad b.: understand and critically evaluate the electronic and structural principles of heterogeneous catalysis, including the physicochemical properties of nanostructured catalytic materials, exhaust gas purification and CO_2 storage. ad c.: analyse advanced electrochemical phenomena and applications in energy research, including specialisations in electrocatalysis, fuel cells and electrolysis cells, as well as theoretical concepts for explaining catalytic reactivity. ad d.: work independently in current areas of research in physical chemistry and interpret results, including characterisation of surface and adsorbate systems, electrocatalytic characterisation, and spectroscopy methods such as IR, Raman, and UV-VIS.
	Prerequisites: none

17.	**Elective Module: Interface and Material Analysis, Cryo-Physical Chemistry and Materials Science Seminar**	**h**	**ECTS-Credits**
	Courses covering 5 ECTS-Credits are to be passed:		
	VO Interface and Materials Analysis Methods for determining the chemical composition of surfaces, interfaces and layer systems: AES, XPS depth profile analysis, adsorption spectroscopy.	1	1.5
	PR Practical Lab Course Interface and Materials Analysis Work with current research methods, e.g. surface and depth profile analysis with X-ray photoelectron spectroscopy (XPS), adsorption spectroscopy.	1	1
	VU Materials in Cryo-Conditions Fundamentals of cryo-chemistry, in particular of aqueous solutions or volatile components resp.: freezing and melting behaviour; freeze concentration; glazing, cold crystallization; applications in astronomy (formation of planets, stars, galaxies of interstellar dust; chemistry of comets),atmospheric chemistry(ice clouds), biology (cryomicroscopy) and medicine (cryonics) and technology (defrosting, artificial snow) and food industry (freeze-drying).	1	1.5
	PR Practical Lab Course on Materials in Cryo-Conditions Working with current research methods, e.g. production and analysis of aqueous solutions under cryogenic conditions, analysis in particular using cryomicroscopy, cryo-X-ray diffraction and cryo-calorimetry; production by vitrification, gas phase deposition or high-pressure cryosynthesis, investigation of freeze-concentrated solutions as well as freeze and exchange damage.	1	1
	SE Current Topics in Materials Science and Physical Chemistry New materials, sustainable energy systems, surface and interface phenomena, modern methods of physical chemistry.	2	2.5
	Total		**5**

	Learning Outcomes: The students are able to ad a.: understand and explain methods for determining the morphology, structure and chemical composition of surfaces and interfaces, including scanning tunnelling microscopy, X-ray photoelectron spectroscopy, depth profiling and adsorption spectroscopy; perform and analyse experimental work in the field of interface and material analysis, including the use of (electrochemical) STM and depth profiling with X-ray photoelectron spectroscopy. ad b.: understand and describe the fundamentals and applications of scanning probe microscopy, atomic force microscopy and other microscopic techniques, including surface potential microscopy, electric force microscopy, friction microscopy and transmission electron microscopy; characterise surfaces at the nanoscopic scale and with atomic resolution, including the use of scanning probe methods, and perform investigations of nanoparticles and layered materials using electron microscopy. ad c.: understand and explain basic and advanced concepts of cryochemistry, in particular of aqueous solutions and volatile components, including freezing and thawing behaviour, freezing concentration, and the phenomena of vitrification and cold crystallisation. place the acquired knowledge in the context of various scientific and technical applications, including its significance in astronomy (e.g. formation of planets, stars and galaxies), glaciology (e.g. glaciers and ice sheets) and the food industry (e.g. freeze-drying). ad d.: work with current research methods in the field of cryochemistry, including the preparation and analysis of aqueous solutions under cryogenic conditions; apply and interpret advanced analytical techniques, in particular methods such as cryomicroscopy, cryo-XRD and cryocalorimetry; use and evaluate various methods for producing materials under cryogenic conditions, including vitrification, gas phase deposition and high-pressure cryosynthesis. ad e: apply current analytical methods in materials science and evaluate physical-chemical systems for energy conversion.
	Prerequisites: none

18.	**Elective Module: Internship**	**h**	**ECTS-Credits**
	To test and apply the acquired knowledge and skills or for orientation on the conditions of professional practice and for acquiring additional competences resp. an internship covering 5 ECTS-Credits (or 120 hours resp.) is passed. The internship must be passed in industrial businesses in materials science or in official institutions. Before starting the internship, it must be approved by the Director of Studies. The institution must attest the duration, scope and contents of the internship. A report about the internship must also be written.	-	5
	Total	**-**	**5**
	Learning Outcomes: Students can apply the knowledge and skills acquired during their studies in materials science and nanoscience in a professional environment, such as in industry or at government institutions. They can identify problems in materials science, develop practical solutions based on their specialist knowledge, and carry out appropriate experiments and analyses to overcome these challenges. They are able to understand and navigate the conditions and requirements of professional practice in the field of materials science. They can recognise the importance of interdisciplinary thinking and action and link their knowledge of materials science with other subject areas in order to develop holistic solutions. They can critically reflect on the experiences and results of their practical work and relate them to their theoretical knowledge. They are able to recognise the relevance of their work for the scientific community and society and can communicate these connections precisely and comprehensibly in a written report. They can evaluate their personal and professional development self-critically and give specific examples		

	of how they have successfully applied their knowledge and skills in a complex professional context.
	Prerequisites: study achievements covering 30 ECTS-Credits

(3) Elective Module: General Skills

1.	**Elective Module: General Skills**	**h**	**ECTS-Credits**
	Courses covering 5 ECTS-Credits are to be passed:		
	a. SE Lecture Series GÖCh/CMBI/Material and Nanosciences Participation in lectures by invited guests as part of the series organised by the Austrian Chemical Society (GÖCh) and/or the Centre for Molecular Biosciences Innsbruck (CMBI) and/or the Centre of Excellence for Materials and Nanosciences.	2	2.5
	b. VO Intellectual Property Rights and Legal Framework of Chemistry: Patent and Chemicals Law Copyright, trademark right, patent law, Austrian and European chemicals law, evaluation and accreditation of chemicals and active agents.	2	2.5
	c. VU Science and Innovation Management Systematic planning, management, organisation and control of innovation processes in companies or organisations, types of innovation, idea evaluation, success factors for innovation, stage-gate process, innovation team, product development, FMEA, strategic innovation management, project definition, tools for planning, organising, implementing and controlling projects, process optimisation, workflow control of processes, case studies from the research and industrial environment .	2	2.5
	d. VU Computer-Aided Database Research Structure and information content of chemical science databases (SciFinder, Beilstein Reaxys, Science of Synthesis – Houben Weyl, esp@cenet, Cambridge Crystallographic Data Centre, etc.); literature search strategies, search algorithms and search profiles, data management.	2	2.5
	e. PR Measurement Technology and Computer-Assisted Control of Experiments Measurement technology, e.g. basic components of analogue/digital (A/D) and digital/analogue (D/A) conversion, programming in LABVIEW.	3	2.5
	f. PR Metal and Ceramics Processing for Laboratory Use Independent working in a precision mechanical workshop.	5	5
	g. PR Glass Processing for Laboratory Use Independent practice of glass-blowing and producing of glass devices for use in the laboratory.	5	5
	h. Interdisciplinary **Skills** Courses worth 5-ECTS credits can be freely chosen from the curricula of the master's and/or diploma programmes offered at the University of	-	5

	Innsbruck, subject to availability. We particularly recommend attending a course that deals with gender aspects and the specialist findings of women's and gender studies.		
	Total	**-**	**5**

	Learning Outcomes: The students are able to ad a: identify current research topics; assess their relevance for the further development of materials science and nanoscience as well as for related fields; recognise how current topics are presented and discussed at a scientific level; critically analyse the quality and scope of scientific presentations and interpret the key messages for your own field; build effective networks and use them to promote your academic and professional development, by participating in the lectures. ad b: demonstrate a critical understanding of key concepts and practices in the field of intellectual property, particularly in the context of chemistry, including patent law, copyright law and trademark law; demonstrate comprehensive knowledge of European chemicals legislation and its implications for the handling and authorisation of chemicals and pharmaceuticals, including handling, authorisation processes and safety standards; critically analyse and evaluate the current state of practice in the field of intellectual property and regulatory frameworks in chemistry, including ongoing developments and challenges in this area. ad c: critically analyse and evaluate innovation processes, including systematic planning, management and control, the evaluation of innovative ideas and the identification of success factors; initiate, plan and successfully implement scientific projects, including clear project definition, the application of suitable tools for planning, organisation and control, and the integration of stage-gate processes; carry out process optimisation in scientific and industrial contexts, including workflow control, the application of FMEA for product development and the analysis of case studies from the research and industrial environment. ad d: conduct critical and comprehensive evaluations and reflections on key theories and methods of computer-assisted database research, including: the structuring of chemical science databases, the main features of databases such as SciFinder, Beilstein Reaxys, and Cambridge Crystallographic Data Centre, and the general structure and information content of these databases; developing, interpreting, and adapting advanced and detailed strategies for searching scientific databases, including: use of various search algorithms, creation of effective search profiles and application of specific search techniques in specialised databases such as Science of Synthesis – Houben Weyl and esp@cenet; systematic analysis, management and critical interpretation of complex data from chemical science databases, including: evaluating the relevance and quality of data, applying data management principles and techniques, and using information resources to solve chemical-scientific problems. ad e: independently analyse and evaluate measurement techniques, including identifying basic components of A/D and D/A conversion, distinguishing between different conversion mechanisms and recognising signal interference. design and implement advanced computer-based systems for experiment control, including developing programmes in LABVIEW, optimising data acquisition systems, and integrating software and hardware components; critically reflect on the applicability and limitations of modern measurement techniques and computer-aided experiment control in real chemical experimentation environments, including the evaluation of data quality, the assessment of system latencies, and the analysis of potential sources of error. ad f: independently deepen your specific knowledge and understanding of metal and ceramic processing, including knowledge of processes, techniques and tools used in precision engineering workshops; identify and analyse problems in precision engineering workshops using analytical skills and scientific working methods, and independently develop solutions, including the selection of suitable tools, materials and techniques for specific applications; apply practical skills in the precision engineering workshop both independently and as part of a team in a confident, efficient and ethically responsible manner, including the manufacture, processing and modification of metal and ceramic components for laboratory applications.

	ad g: apply glassblowing techniques, including recognising different types of glass, selecting appropriate techniques for specific requirements, and considering safety aspects when working with glass; independently design and manufacture glass apparatus for laboratory applications, including implementing specific laboratory configurations, applying joining techniques, and complying with standards for laboratory apparatus; develop and implement solutions to glass-related problems in the laboratory environment, including dealing with unforeseen challenges during glassblowing, adapting techniques to specific requirements, and integrating glass apparatus into multidisciplinary laboratory projects. ad h: personalise and deepen your subject profile by acquiring additional qualifications, establishing connections to your own specialist knowledge and demonstrating critical awareness of specialist topics at the interface between different areas. You will have additional and in-depth skills, abilities and additional qualifications.
	Prerequisites: none

§ 10 Master's Thesis

(1) A Master's Thesis corresponding to 20 ECTS-Credits must be written in the Master's Programme of Materials and Nanoscience. The Master's Thesis is a scientific paper, which proves the ability to independently deal with a scientific topic (content and methodology) with appropriate scientific methods.

(2) The topic of the Master's Thesis may be chosen from the fields of materials science and nanoscience, inorganic chemistry, materials technology, mineralogy, pharmaceutical technology, physics, physical chemistry, textile chemistry and textile physics, and theoretical materials science.

(3) Precondition for announcing the topic for the Master's Thesis is the proof of a minimum of 60 ECTS-Credits passed in compulsory and elective modules.

(4) The completed Master's Thesis must be submitted to the Director of Studies in electronic form. It must be accompanied by a sworn affidavit confirming that the rules of good scientific practice have been followed.

§ 11 Examination regulations

(1) A module is completed by the positive evaluation of its courses.

(2) The courses of the modules are evaluated by means of course examinations. Course examinations serve to demonstrate the knowledge and skills acquired in a single course, whereby

1. in the case of courses without continuous performance evaluation, the assessment is based on a single examination at the end of the course.
2. in the case of courses with continuous performance evaluation, the assessment is based on at least two written, oral and/or practical contributions of the participants.
3. In the case of course examinations, the course instructor must fix the examination method (written/oral/practical work) and the evaluation criteria before the start of the semester.

(3) The performance assessment for the Internship module shall be carried out by the Director of Studies on the basis of the written report on the internship. Positive evaluation reads "participated with success", negative evaluation "participated without success".

(4) The Compulsory Module Preparation of the Master's Thesis is evaluated by the supervisor of the Master's Thesis based on a synopsis Positive evaluation reads "participated with success", negative evaluation "participated without success".

(5) Assessment of the Compulsory Module Master's Thesis Defence" is based on an oral exam before an examination board consisting of at three examiners.

(6) Modules taken from other study programmes are subject to the examination regulations of the curriculum they are taken from.

§ 12 Academic degree

Graduates of the Master’s Programme Functional Materials Science are awarded the title “Master of Science“, shortened to “MSc”.

§ 13 Coming into force

(1) This curriculum comes into force on 1 October 2025.

(2) The changes of the curriculum as published in the University of Innsbruck Bulletin of 18 February 2026, Issue 38, No. 353 come into force on 1 October 2026 and are to be applied to all students.

§ 14 Transitional provisions

(1) This curriculum applies to all students beginning the Master’s Programme in Functional Materials Science as of the 2025/26 winter semester.

(2) Regular degree students who have started the Master’s Programme in Materials and Nano Sciences, published in the University of Innsbruck Bulletin of 25 November 2008, Issue 12, No. 80, last changed on 28 June 2019, Issue 66, No. 580 before 1 October 2025, are entitled from this point in time to finish this study programme within a maximum of six semesters.

(3) If the Master’s Programme in Materials and Nano-Sciences is not completed in time, the students are subject to this curriculum.

(4) In any case, the students are entitled to subject to this curriculum on a voluntary basis anytime.