Note:
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Curriculum for the

Master's Programme Materials and Nano-Sciences

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

§ 1 Qualification profile

(1) The Master's Programme Materials and Nano-Sciences is part of the cluster of natural science studies.

(2) The Master's Programme Materials and Nano-Sciences is structured on an interdisciplinary basis. With the emphasis on the areas of Design, Synthesis and Analysis of Advanced Materials, and with particular attention to nano-structured materials, the programme is aimed at graduates of Chemistry, Pharmacy, Physics, Geo- and Atmospheric Sciences, as well as to graduates of Engineering and Environmental Engineering, and qualifies them to solve, based on the latest standards in research, complex problems of interdisciplinary research and application fields of modern Materials Sciences and to apply their theoretical knowledge in practice. The inclusion of Nano-Sciences and its deep anchoring in the basic disciplines of Chemistry and Physics complement the training of civil engineers in the area of classical working materials. A comprehensive range of advanced specialist modules widens the graduates' knowledge of their subject with an eye on their desired career aims and/or future doctoral studies.

(3) The established interdisciplinary and research-based education enables graduates to work in a task-oriented way. The wide range of the training and the interdisciplinary skills taught open a broad spectrum of career opportunities in industry, research institutes, universities and in the public services to the graduates. The most important occupational fields are material development in university and industrial research, material analysis and quality assurance as well the material testing and the patent system. The specialist competences taught open up career paths in the chemical industry, in the semi-conductors industry, in metal production and processing firms, in light technology and optics, as well as in energy technology, sensorics and many other branches.

§ 2 Scope and duration

The Master's Programme Materials and Nano-Sciences covers 120 ECTS-Credits. This corresponds to a duration of the study programme of four semesters. One ECTS-Credit corresponds to a workload of 25 hours.

§ 3 Admission

(1) Admission to the Master's Programme Materials and Nano-Sciences requires a relevant Bachelor's degree awarded by a University or a University of Applied Sciences ("Fachhochschule") or a relevant degree acquired at a recognised post-secondary educational institution home or abroad.

(2) Relevant Bachelor's degrees are in any case Civil Engineering, Chemistry, Pharmacy, Earth Science, Geo- or Atmospheric Sciences or Physics at the University of Innsbruck. The rectorate decides based on the regulations of the Universities Act on the admission to the Master's Programme in case of another relevant study programme or the equivalence of a study programme at an approved post-secondary educational institution home or abroad.

(3) In the event that equivalence has been established in principle but with certain qualifications missing for full equivalence, supplemental examinations may be required by the rectorate. These examinations must be passed during the master's programme.

§ 4 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. No maximum number of participants.

(2) Courses with continuous performance assessment:

1. **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
2. **Practical courses** (UE) focus on the practical treatment of concrete scientific tasks within an area. Maximum number of participants: 30
3. **Seminars** (SE) provide in-depth treatment of scientific topics through students' presentations and discussion thereof. Maximum number of participants: 60
4. **Lectures with practical elements** (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
5. **Practical training courses** (PR) provide practical experience with concrete scientific tasks, complementing occupational and academic training. Maximum number of participants: 10

§ 5 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 criterion in No. 1 does not suffice, first, students who pass this course as part of a compulsory module come first, then students that pass the course as part of an elective module.
3. If the criteria in No. 1 and No. 2 do not suffice, then the time of meeting the requirements for the course is taken into account.
4. If the criteria in No. 1, No. 2 and No. 3 do not suffice for the regulation of places, then the grade achieved in the module which is a precondition for the respective course is taken into account.
5. If all the criteria listed before do not suffice for regulating admission, then the places are raffled.

§ 6 Compulsory and elective modules

(1) The Master's Programme Materials and Nano-Sciences is divided into the following groups of modules:

1. Compulsory modules in the disciplines of Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physics, Ion Physics, Engineering Sciences and Theoretical Materials Science (65 ECTS-Credits).
2. Elective modules in "Advanced Specialisation" of the disciplines of Inorganic Chemistry, Physical Chemistry, Mineralogy, Organic Chemistry, Pharmaceutical Technology, Physics, Ion Physics, Textile Chemistry and Textile Physics, Building and Engineering Sciences and Theoretical Materials Science. From these elective modules students must pass modules corresponding to 20 ECTS-Credits.
3. Elective modules in general competences. From these elective modules, modules corresponding to 5 ECTS-Credits must be passed.
4. Compulsory Module "Master's Thesis Defense" (2.5 ECTS-Credits) and Compulsory Module "Preparation of the Master's Thesis" (7.5 ECTS-Credits).

(2) Compulsory modules in the disciplines Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physics, Ion Physics, Building and Engineering Sciences and Theoretical Materials Sciences. The following modules corresponding to 72.5 ECTS-Credits must be passed:

1.	**Compulsory Module: Cross-Sectional Competences for Materials and Nano-Sciences**	**h**	**ECTS-Credits**
	PS Cross-Sectional Competences Contents from the Bachelor's Programmes in Chemistry, Physics, Mineralogy and Engineering Sciences must be passed as agreed with the Associate Dean of Studies to complete the Bachelor's programme.	1	10
	Total	**1**	**10**
	Learning Outcomes: Students acquire multidisciplinary skills in materials and nano-sciences.		
	Prerequisites: none		

2.	**Compulsory Module: Structural Materials of Nano-Sciences**	**h**	**ECTS-Credits**
a.	**VO Introduction to Materials and Nano-Sciences** Phenomenology, physical properties and conceptual descriptions of-nanoscale matter	1	1
b.	**VO Inorganic Materials** Within the scope of the course important materials in technical mineralogy, their production and properties are introduced. Focus is on ceramic materials, inorganic glasses, glass ceramics and hydraulic and non-hydraulic binding agents	3	6
c.	**VO Solid State Chemistry II** Introduction to inorganic functional materials relevant for materials science with emphasis on, hard materials, alloys and nano-scale working materials. Besides of synthesis, the focus is particularly on the technically relevant electronic, mechanical, optical and magnetic properties of these materials	2	3
	Total	**6**	**10**
	Learning Outcomes: Students gain knowledge of chemical, physical and structural properties of inorganic materials and their nanostructured types.		

	Prerequisites: none

3.	Compulsory Module: Phases 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.	**VO 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** Determining latent heat, heat capacities, expansion coefficients, compressibilities, critical phenomena, solid-solid transitions, P-V-T-analyses of fluid inclusions, thermoanalytical methods, dilatometry, heat microscopy, high-temperature diffraction and Raman spectroscopy, high-pressure experiments and spectroscopy	2	2
	Total	**4**	**5**
	Learning Outcome: Students advance their knowledge in thermodynamics and learn to apply it to materials. Understanding of kinetic processes and the theory of phase transitions; The students master experimental methodology for characterising phase transitions.		
	Prerequisites: none		

4.	Compulsory Module: Structure of Crystalline Materials	h	ECTS-Credits
a.	**VO Cristallographic Diffraction Methods** Theory of structure determination of materials by diffracting rays: x-rays, synchroton radiation, neutrons, electrons, powder diffraction; use of crystallographic databases	3	6
b.	**PR Lab Practice on Diffraction Methods** Methods of single-crystal x-ray structural analysis, and powder diffraction, interpretation and computer-assisted analysis, data visualisation	2	1.5
	Total	**5**	**7.5**
	Learning Outcomes: Students get to know the theory and practice of diffraction methods for determining the structures of materials.		
	Prerequisites: none		

5.	Compulsory Module: Mechanical Properties	h	ECTS-Credits
a.	**VU Mechanics of Materials** Characterisation of the micro-structure of materials and the behaviour of the single phases as well as modelling of mechanical material behaviour that can be conducted from it; experimental characterisation and model formation of chemical and physical processes within the scope of their production and their effects on the microstructure of the materials and the possible mechanical properties	2	3

b.	**PR Characterisation of Mechanical Material Properties** Experimental recording of deformations; stability and elastic material properties; conception of measurements, analysis and interpretation of measurements	1	2
	Total	**3**	**5**
	Learning Outcomes. Students are able to characterise the structure and micro-structure of materials and the resulting mechanical properties. Moreover, they learn about the underlying chemical and physical processes in the production process and the resulting possibilities of a targeted manipulation of mechanical material behaviour. They are able to apply experimental methods for recording microstructures and determining mechanical parameters.		
	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 nano-scale 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 dependency 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: Students acquire theoretical and practical competences in modern methods of nano-structural analysis and optical properties of solid state materials.		
	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: Students understand the principles of electrochemistry in aqueous and solid electrode/electrolyte systems and of low- and high-temperature corrosion processes on the basis of a thermodynamic, kinetic and solid-state-electro-chemical description.		
	Prerequisites: none		

8.	**Compulsory Module: Spectroscopy and Group Theory**	**h**	**ECTS-Credits**
a.	**VU Group Theoy** Group theory concepts, representation theory, character tables, symmetry groups, point groups, space groups, symmetry breaking, projection operator methods and applications in optical and vibration spectroscopy, electronic structure and phase transitions	2	3
b.	**VU Introduction to Spectroscopy** Particle-wave-duality 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: Students master the symmetry analysis of problems and acquire a deeper understanding of matter and solid state properties and spectroscopies (IR, optical spectroscopy, etc.).		
	Prerequisites: none		

9.	**Compulsory Module: Polymer Materials**	**h**	**ECTS-Credits**
a.	**VO Polymer Chemistry** Structure of polymer materials, polymer reactivity, physical and chemical data of polymer materials, technical properties, technical polymers as materials, composite materials and lightweight materials, technical textiles, functional polymers. Integrated aspects: LCA, recycling, disposal	1	1.5
b.	**VO Polymer Analytics** 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	**2**	**2.5**
	Learning Outcomes: Students are familiar with the chemical and structural properties of polymer materials, understand the theoretical concepts for describing polymer solid state materials and know the fundamentals of their use in technological engineering.		
	Prerequisites: none		

10.	Compulsory Module: Solids: Basic Concepts and Technology	h	ECTS-Credits
a.	**VU Solid State Materials Technology** Structure, lattice oscillations, electronic properties, transport properties; metals, isolators, semiconductors, magnetism, correlation phenomena	2	2.5
b.	**PR Transport Properties** Determination of important material properties of solids for transport (charge, warmth or material transport), e.g. electric conductivity, heat conductivity, Hall conductivity, mobility, charge carrier concentration, excitation energies, bandgap	1	1
c.	**VO Amorphous Materials** Amorphous materials in nature and technology (oxidic glass, amorphous polymers, organic glass, (semi)metallic glass, amorphous ice); material properties and fields of use; production of amorphous materials; structure models of amorphous materials, demarcation to crystals and nano-crystals; phase transitions, in particular the glass transition of amorphous materials; transition change technology; historic and modern glass production and processing; technical glass (safety glass, heat-absorbing glass, light-blocking glass, smart glass, glass fibres, etc.)	1	1.5
	Total	**4**	**5**
	Learning Outcomes: Students understand the interconnections between solid state material structure, possible excitations of these structures and the macroscopic material properties. The learn fundamental technologies for making semi-conductor building elements and acquire knowledge of magnetic and other materials with electron correlation. Students then apply their theoretic knowledge in practice and practice the experimental determination of the listed material properties. Students are familiar with the chemical and structural properties of amorphous and polymer materials, understand the theoretic concepts for describing non-crystalline solids and know the fundamentals of use in technical engineering.		
	Prerequisites: none		

11.	Compulsory Module: Computer-Assisted Materials Science	h	ECTS-Credits
a.	**VO Introduction to Computer-Assisted Materials Science** Polarizability and multi-body effects, reactive fields of force, periodic approaches in quantum mechanics, density function theory, examples of application	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: Students acquire basic knowledge and practical experience in dealing with modern numerical methods for calculating material properties.		
	Prerequisites: none		

12.	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 (abstract) 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: After successful completion of this module, the students will be able to write a brief summary of the content of the planned Master's Thesis (abstract), to outline an anticipated schedule and to conclude a written Master's Thesis agreement.		
	Prerequisites: none		

13.	Compulsory Module: Master's Thesis Defense (Defensio)	h	ECTS-Credits
	Presentation and defense of own's own Master's Thesis (Defensio) within the scope of a 20-minute scientific presentation and a subsequent scientific discussion and questioning by a examination board.		2.5
	Total		**2.5**
	Learning Outcomes: Students present and defend their Master's Thesis within the scope of a scientific presentation.		
	Prerequisites: successful evaluation of the required modules and the Master's Thesis		

(3) Elective modules in "Advanced Specialisation" in the subdisciplines of Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physics, Ion Physics, Textile Chemistry and Textile Physics, Civil Engineering and Theoretical Materials Sciences: From elective modules 1 – 19 modules covering 20 ECTS-Credits must be selected and passed:

1.	Elective Module: Cluster and Nano Particles	h	ECTS-Credits
a.	**VO Nano and Cluster Physics** Introduction to cluster physics, production and characteristics of clusters, free and deposited clusters and nano particles.	2	2.5
b.	**PR Nano- and Cluster Physics** Practical experiments on jets, mass spectronomy of free clusterions and films of deposited nano-particles.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The participants acquire basic theoretical and experimental knowledge of the physics of clusters and nano-particles. Production, characteristics and application of clusters as technical materials with novel properties are communicated, both theoretically in the lecture and by practical experiments.		
	Prerequisites: none		

2.	Elective Module: Plasma and Thin Film Technology	h	ECTS-Credits
a.	**VU Applications of Plasma** Introduction to plasma physics, technology and diagnostics, basics of plasma chemistry, plasma methods for the synthesis of new materials	2	2.5
b.	**PR Plasma Processes in the Production of Thin Layers** Practical experiments on plasma devices for the diagnosis, characterisation and control of plasmas and their application in coating technology.	2	1.5
c.	**PR Thin Film Technology, Chemical Vapour Deposition** Calculation and production of functional thin film systems by evaporation deposition	1	1
	Total	**5**	**5**
	Learning Outcomes: Students have basic theoretical and experimental knowledge of plasma physics, diagnosis and technology, can deal with the resp. plasma apparatus and know about plasma technology application in materials and nano-sciences. They learn how to calculate functional thin film systems, get to know different deposition techniques and control the material properties of the produced product.		
	Prerequisites: none		

3.	Elective Module: Materials Analysis	h	ECTS-Credits
a.	**VU IR-Spectroscopy for Materials and Nano Science** Theoretical fundamentals of infrared spectroscopy, structure of a FTIR-spectrometer, identification of element families, quantitative IR-spectroscopy	1	1.5
b.	**VU Raman-Spectroscopy for Materials and Nano Science** Theoretical fundamentals of Raman-spectroscopy, functioning of the Raman spectrometer, practical work on the apparatus	1	1.5
c.	**VU Thermoanalysis and Calorimetry for Materials and Nano Science** Theoretical basis and measurement principles of thermos-analytical processes, such as differential thermoanalysis, differential scanning calorimetry, thermogravimetry, thermomicroscopy, thermomechanical analysis as well as isothermic microcalorimetry; possible uses for different classes of materials; the practice of measurement and data evaluation	1	1
d.	**VU X-Ray Fluorescence for Materials and Nano Science** Theoretical basis of X-ray fluorescence, structure and/measurement technology of the wavelength and energy dispersing RFA, preparation of samples and quantitative analysis for diverse materials, standardisation processes and correction methods	1	1
	Total	**4**	**5**
	Learning Outcomes: Students acquire detailed knowledge and practical experience with modern materials analytical methods, their optimal areas of application and limits.		
	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 High Pressure Materials** Practical exercises with hydrothermal apparatuses, piston-cylinder presses, multi-anvil presses and diamond anvil cells	2	2
	Total	**4**	**5**
	Learning Outcomes: Students master high pressure methods as a synthesis method for advanced materials.		
	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 Practical Course in Applied High-Pressure Solid State Chemistry** Experimental execution of modern high-pressure synthesis, (multi-anvil technology), The focus lies on current issues in the synthesis of new functional materials.	2	3
	Total	**3**	**5**
	Learning Outcomes: The students are familiar with current field of research in modern solid state chemistry. They acquire advanced practical competences for producing solid state functional materials with high-temperature and high-pressure synthesis.		
	Prerequisites: none		

6.	Elective Module: Tribology / Materials and Surface Science Technology	h	ECTS-Credits
a.	**VU Micromechanics of Materials** Micromechanic methods for determining physical properties of materials based on material morphology and single phase behaviour; application on issues in material engineering; material and surface characterisation within the scope of the NanoLab of the University of Innsbruck	2	2.5
b.	**VO Friction and Lubrication** Classic concepts of friction, contact mechanics, elastic and plastic deformations, microscopic mechanism of solid-solid friction, static friction and dynamic friction, stick-and-slip motion, hydrodynamic and elastohydrodynamic friction, interfacial lubrication, additive, surface melting, capillary action	2	2.5
	Total	**4**	**5**

	Learning Outcomes: Students learn - based on selected methods of micromechanics - about fundamental concepts of tribology. They understand the origin of physical properties in dependence of material morphology and the properties of the individual material phases as well as the elemental processes of friction on a nanoscopic and molecular scale. They are able to describe the material behaviour based on microstructure and to determine the sensitivity of the behaviour in case of change of structure and morphology on the one hand and quantitative treatment of friction loss and its targeted regulation by different types of lubrication on the other hand.
	Prerequisites: none

7.	Elective Module: Cement and Concrete Technology	h	ECTS-Credits
a.	**VU Cement and Concrete Technology I** Cement, cement stone, hydration, rock granulation, concrete additives, unset concrete, concrete formula, solid concrete, mechanical qualities, light concrete, mortar, durability, concrete testing, concrete norms	2	2.5
b.	**VU Concrete Technology II** General concrete technology, HPC-high performance concrete, highly solid concrete, SCC-self-consolidating concrete, production of thick and moderately thick and bulky concrete building parts, jet concrete/building with jet concrete, steel-fibre reinforced shotcrete, concrete curing, concrete durability, ready-mixed concrete, fair-faced/coloured concrete, sheeting, concrete damages, examples from practice	2	2.5
	Total	**4**	**5**
	Learning Outcomes: Students acquire basic knowledge on the production and applications of concrete (cement and hydro products, rock granulation and their qualities, concrete additives, fresh and solid concrete, the chemical binding process of cement and the material qualities resulting therefrom, durability, required norms and guidelines for concrete testing); Students are made familiar with the requirements and production of special concrete types of concrete in the building trade and they learn about new developments in concrete technology.		
	Prerequisites: none		

8.	Elective Module: Degradation of Materials and Analysis of Damage	h	ECTS-Credits
a.	**VU Degradation Mechanisms and Damage Analysis** Description of mechanisms of materials degradation, damage analysis at the NanoLab of the University of Innsbruck an analysis of damages; registration of the state of a building material and monitoring, norms and state of technology	2	2.5
b.	**VU Modelling and Simulation** Modelling and simulation of degradation processes in materials due to mechanical strain and chemical and thermal effects on materials; experimental modelling and quantification of degradation processes for the validation of the model; demonstration of solutions to practical tasks	2	2.5
	Total	**4**	**5**
	Learning Outcomes: Students learn about central issues of material engineering in relation to the durability of materials and damage analysis for determining and describing underlying damage mechanisms.		

	The students are able to model and simulate mechanically-, chemically- and thermally-induced damaging processes and to validate the models and results won with experimental methods.		
	Prerequisites: none		

9.	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 manufacturing and processing of composites, technical textiles: materials for medical applications, filter materials, building engineering, plastics technology, lightweight vehicles construction, aviation and space travel, conveyance and transport (materials, requirements, technical execution)	2	2.5
	Total	**4**	**5**
	Learning Outcomes: Students possess fundamental an experimental knowledge on fibre polymers, composites and technical textiles, structures won from them, their characterisation, modification and the required processing techniques.		
	Prerequisites: none		

10.	Elective Module: Colour 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: Students get basic theoretical knowledge on polymer additives and colourants as well as experimental knowledge on technology of fibre polymers, structures won from them, their characterisation and modification, processing techniques and material characterisation.		
	Prerequisites: none		

11.	Elective Module: Theoretical Methods in Materials Sciences	h	ECTS-Credits
a.	**VO Computer-Assisted Design of Materials** Advanced methods for describing solid states; methods for describing polarisation effects and multi-body interactions; reactive force field methods for applications in materials science; fundamentals of the finite-elements method	1	1

b.	**VO Correlated Methods** Methods for treating correlated and strongly correlated systems; quantum theory of multi-electron systems; numeric methods for solving the Schrö-dinger equation; density functional theory; examples	1	2
c.	**PR Computer-Aided Assessment of Materials** Computer-aided design of materials; introduction to resp. programmes; quantum mechanical and force-field-based calculation of solid state bod-ies and surfaces of solids	2	2
	Total	**4**	**5**
	Learning Outcomes: Students acquire knowledge for using methods of quantum mechanics, modelling processes and simulation techniques for calculating the properties of materials of all kind and learn the most important approaches for producing quantitative structure/electronic structure-prop-erty/relationships as a basis for designing new chemical compounds or materials.		
	Prerequisites: none		

12.	**Elective Module: Applied Mineralogy**	**h**	**ECTS-Credits**
a.	**VO Mineral Raw and High Performance Materials for Materials and Nano Science** In the first part of the lecture the global distribution and genesis of metal and industrial mineral reservoirs (ore, steel refiners, light metals, non-ferrous metals, special metals and bauxite, clays, sands, carbon etc.) as well as the use of ore for materials is discussed. In the second part aspects of raw material economy and sustainable exploration, exploitation and use of raw and (basic) materials are deal with. The third part deals with industrial manufacturing and the properties of metals (iron, types of steel etc.).	3	4
b.	**UE Mineral Raw and High Performance Materials for Materials and Nano Science** Advanced study of the contents of the lecture with selected examples.	1	1
	Total	**4**	**5**
	Learning Outcomes: Students acquire knowledge relating to reservoirs and aspects of raw materials science.		
	Prerequisites: none		

13.	**Elective Module: Advanced Crystallography**	**h**	**ECTS-Credits**
a.	**VU Methods of Powder Diffraction** Selected chapters of powder diffraction and diffraction analysis of poly-crystalline materials in the field of materials sciences are introduced. Ex-amples are among others the quantitative phase analysis of crystalline mixtures, determination of amorphous parts, determination of crystallite size, microstrain examinations for determining real parameters, in-situ diffraction measurement in laboratories and large research institutions for describing temperature- and pressure-related reactions and their analysis.	2	2.5
b.	**VU Selected Chapters of Structural Reserach** The course aims at introducing to the description and analysis of solid state bodies with an aperiodic strucuture or a more or less disturbed long-	2	2.5

	rage order. Among this bodies are quasicrystals, modulated structures and compounds with strongly deviating orders.		
	Total	**4**	**5**
	Learning Outcomes: Within the scope of this module deals flexibly with current trends in diffraction analysis of monocrystalline and polycrystalline solid state bodies. The students acquire knowledge beyond the knowledge gained in the compulsory module Structures of Crystalline Materials.		
	Prerequisites: none		

14.	**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 characteristics 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, Chemography of solid-state body reactions; thermodynamic modelling of chemical systems of function of P, T and X (chemical composition). Phase diagrams and pseudosections 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: Imparting of physical and thermodynamic aspects of crystalline phases		
	Prerequisites: none		

15.	**Elective Module: Materials Science Seminar**	**h**	**ECTS-Credits**
	SE Current Topics in Materials Science and Physical Chemistry New materials, sustainable energy systems, surface and interfacial phenomena, modern methods of physical chemistry	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: The students investigate current and socially relevant research in physical chemistry and improve their presentation skills.		
	Prerequisites: none		

16.	**Elective Module: Nanostructures and Boundary Surfaces 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 binding to surfaces in the MO-picture, band structure and density of states, catalysis, volcano plot	1	1

		h	ECTS-Credits
b.	**VU Energy Engineering and Catalysis** Electronic and structural principles of heterogenous catalysis, physical-chemical properties of nano-structured catalytic materials, environmental catalysis, waste gas purification, processes for chemically storing and converting energy, co2 storage and use	1	1
c.	**VU Electrochemistry and Applications in Energy Research** Advanced studies of examination methods (e.g. rotating (ring) disc-electrode, electro-chemical impedance spectroscopy, semiconductor electrochemistry (e.g. Mott-Schottky analysis), fundamentals of electro-analysis an Li-ion insertion and applications (e.g. fuel cells or Li-ion batteries)	1	1
d.	**PR Current Research in Physical Chemistry** Working in current research in a selected physical chemistry working group selected by the students, e.g. characterisation of structure examination of surface- and nano-structured adsorbate systems (LEED, STM, ARUPS), catalytic CO2-hydration to energy carriers, reformation of energy carriers for hydrogen generation, product analysis (MS, GC), catalyst characterisation of SOFC-relevant materials, electrocatalysis and battery research, photo-electrochemistry	2	2
	Total	**5**	**5**
	Learning Outcomes: Students acquire advanced knowledge and knowledge of the interrelations between the electronic and geometric structure of surfaces and the kinetics and dynamics of surface reactions. They gain advanced knowledge of surface and nano sciences relevant for energy and environmental-engineering and of heterogenous catalysis (environmental catalysis, chemical energy storage and energy conversion,CO2 storage and use). Students learn applications of electrochemical thermodynamics and kinetics with focus on applications in energy research, e.g. batteries, fuel cells and solar cells.		
	Prerequisites: none		

17.	**Elective Module: Cryo-Physical Chemistry**	**h**	**ECTS-Credits**
a.	**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
b.	**PR Practical Lab Course on Materials in Cryo-Conditions** Working with current research methods, e.g. making and analysis of aqueous solutions in cryo-conditions, analysis, in particular with cryo-microscopy, cryo-XRD and cryo-calorimetry; production with vitrification, chemical vapour deposition or high-pressure cryo-synthesis	1	1
	Total	**2**	**2.5**
	Learning Outcomes: Students acquire knowledge about the behaviour of materials under cryogenic conditions and experimental control of material properties.		
	Prerequisites: none		

18.	Elective Module: Interface and Materials Analysis	h	ECTS-Credits
a.	**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
b.	**PR Practical Lab Course Interface and Materials Analysis** Working with current research methods, e.g. surface and depth profile analysis with X-ray photoelectron spectroscopy (XPS), adsorption spectroscopy	1	1
	Total	**2**	**2.5**
	Learning Outcomes: Students acquire theoretical and practical knowledge about the application of modern techniques of interface and materials analysis for technically relevant issues.		
	Prerequisites: none		

19.	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 internhsip must also be written.	-	5
	Total	**-**	**5**
	Learning Outcomes: Students use acquired knowledge and skills in a working environment. Having finished the module, the students know about the conditions of the professional and/or scientific practice.		
	Prerequisites: approval by the Director of Studies		

(4) Elective modules: General Competences

From the elective modules 20 – 27 modules corresponding to 5 ECTS-Credits must be selected:

20.	Elective Module: Lecture Series Materials and Nano-Sciences/Austrian Chemical Society/Inorganic Chemistry Colloquium/Physical Chemistry Colloquium/Earth Sciences Colloquium/Construction Engineering Sciences Colloquium	h	ECTS-Credits
	SE Lecture Series Attendance of Materials and Nano Sciences lectures by guest lecturers from the Association of Austrian Chemists (GÖCh), the Inorganic Colloquium, the Physical Colloquium and Earth Science Colloquium or the Colloquium of Building Engineers.	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: By participating in lectures, students are familiarised with current research topics by external experts and learn how current topics are presented and discussed scientifically. Through the contacts with the invited speakers, the students get to know the scientific community.		

	Prerequisites: none

21.	Elective Module: Intellectual Property and Regulatory Framework in Chemistry	h	ECTS-Credits
	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
	Total	**2**	**2.5**
	Learning Outcomes: Students gain an understanding of the intellectual property law relevant for chemists and an overview of the legal fundamentals for working with chemicals.		
	Prerequisites: none		

22.	Elective Module: Project Management	h	ECTS-Credits
	VU Project Management Project definition, project management approaches and processes; practice-oriented tools for planning, organising, implementing and controlling of projects; examples from the field of research and industry relevant for chemistry	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: Students understand the importance, methodology and success factors of modern project management and learn to apply management processes and helpful tools for their own projects. The acquired competences enable the students to take on an active role in project organisation.		
	Prerequisites: none		

23.	Elective Module: Interdisciplinary Skills	h	ECTS-Credits
	Courses corresponding to 5 ECTS-Credits are selected from the courses of the Masters' Programmes at the University of Innsbruck or from the field of "Equality and Gender".		5
	Total		**5**
	Learning Outcomes: Further qualification of the students as chosen by them.		
	Prerequisites: The registration requirements specified by the respective curricula must be met.		

24.	Elective Module: Computer-Aided Database Research	h	ECTS-Credits
	VU Computer-Aided Database Research Structure and information contents of natural scientific databases (SciFinder, Beilstein Reaxys, Science of Synthesis – Houben Weyl, esp@cenet, Cambridge Crystallographic Data Centre etc.); Strategies of literature research, search algorithms and search profiles, data management	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: Students acquire application-oriented knowledge of the contents and information search in natural scientific databases.		
	Prerequisites: none		

25.	Elective Module: Measurement Technology and Computer-Assisted Control of Experiments	h	ECTS-Credits
	PR Measurement Technology and Computer-Assisted Control of Experiments Measurement technology, e.g. basic competences of A/D and D/A conversion, programming with LABVIEW	3	2.5
	Total	**3**	**2.5**
	Learning Outcomes: Participants get to know hard- and software (programming) for capturing measurement data and controlling experiments.		
	Prerequisites: none		

26.	Elective Module: Metal and Ceramics Processing for Laboratory Use	h	ECTS-Credits
	PR Metal and Ceramics Processing for Laboratory Use Independent working in a precision mechanical workshop	5	5
	Total	**5**	**5**
	Learning Outcomes: Participants learn methods and skills resp. of precision mechanics and are able to independently make precision elements and apparatuses.		
	Prerequisites: none		

27.	Elective Module: Glass Processing for Laboratory Use	h	ECTS-Credits
	PR Glass Processing for Laboratory Use Independent practice of glass-blowing and producing of glass devices for use in the laboratory.	5	5
	Total	**5**	**5**
	Learning Outcomes: Participants learn methods of glass processing and are able to independently make glass devices for laboratory use.		
	Prerequisites: none		

§ 7 Master's Thesis

(1) A Master's Thesis corresponding to 20 ECTS-Credits must be written in the Master's Programme of Materials and Nano Sciences. 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 can be selected from all fields of Materials and Nano Science, in particular Inorganic Chemistry, Engineering Sciences, Ion Physics, Mineralogy, Pharmaceutical Engineering, Physics, Physical Chemistry, Textile Chemistry and Textile Physics as well as Theoretical Materials Science. 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.

(3) The Master's Thesis must be handed in in writing as well as in an electronic form as specified by the Director of Studies.

(4) To enable the students to complete writing the Master's Thesis within 6 months (corresponds to 30 ECTS-Credits) acc. to §81 (2) Universities Act, the students must pass the "Preparation of the Master's Thesis" (corresponding to 7.5 ECTS-Credits) prior to working on their Master's Thesis (20 ECTS-Credits). The study programme is completed with the Master's Thesis Defense (corresponding to 2.5 ECTS-Credits).

§ 8 Examination Regulations

(1) Modules are evaluated by module examinations. Module examinations are examinations that serve to prove the knowledge and skills acquired in a module. If all parts of a module examination have been positively evaluated, the respective module is passed.

(2) The courses of the modules are evaluated by means of course examinations. Course examinations are

1. examinations that serve to demonstrate the knowledge and skills gained in a single course and where the performance is assessed with a single exam at the end of the course. The course lecturer must communicate the examination method (written or oral) and the evaluation criteria before the start of the course.
2. examinations on courses with continuous performance assessment, where the evaluation is based on the student's regular, written and/or oral contributions.

(3) The course lecturers must inform the students on the objectives, contents and methods used in their courses as well as on the evaluation criteria and examinations in a suitable way before the start of the semester.

(4) The compulsory module "Preparation of the Master's Thesis" is evaluated by the supervisor of the Master's Thesis based on an exposé. Positive evaluation reads "successfully completed", negative evaluation "unsuccessfully completed".

(5) Assessment of the compulsory module "Master's Thesis Defense" is based on an oral exam before an examination board consisting of at least three examiners.

§ 9 Academic Title

Students completing the Master's Programme Materials and Nano Sciences are awarded the title "Master of Science", shortened to "MSc".

§ 10 Coming into force

(1) The curriculum is effective as of 1 October 2009.

(2) § 6 as published in the University of Innsbruck Bulletin of 8 June 2011, Issue 26, No. 461, is effective as of 1 October 2011 and applies to all students.

(3) The modification of the curriculum in the version of the University of Innsbruck Bulletin of 9 May, Issue 27, No. 397 comes into effect on 1 October 2016 and is to be applied to all students.

(4) The changes of the curriculum acc. to the version of the University of Innsbruck Bulletin of 28 June 2019, Issue 66, No. 580 come into effect on 1 October 2019 and are to be applied to all students.

Appendix 1: Recommended study plan

As a result of the wide range of electives for the Master's Programme Material and Nano-Sciences, a detailed study plan with a list of courses chosen is not very useful. The time sequence for the subjects chosen is in line with the semester course offerings (winter or summer semester) and the actual choice of module is decided by the students themselves. Below is an overview plan in line with the relative workload in terms of ECTS-AP:

<table>
<tr><th>1st Semester
(Winter Semester)</th><th>2nd Semester
(Summer Semester)</th><th>3rd Semester
(Winter Semester)</th><th>4th Semester
(Summer Semester)</th></tr>
<tr><td colspan="3">Compulsory modules
(12 Modules, 75 ECTS-Credits)
Inorganic Chemistry, Physical Chemistry, Mineralogy, Pharmaceutical Technology, Physic, Ion Physics, Buildings and Engineering Sciences and Theoretical Materials Sciences</td><td rowspan="3">Master's Thesis
(27.5 ECTS-Credits)

Defense of the Master's Thesis
(2.5 ECTS-Credits)</td></tr>
<tr><td colspan="3">Elective Modules of the Subject Intensification
(14 Modules, Selectin of 10 ECTS-Credits)
Inorganic Chemistry, Physical Chemistry, Mineralogy, Organic Chemistry, Pharmaceutical Technology, Physics, Ion Physics, Textile Chemistry and Textile Physics, Building and Engineering Sciences and Theoretical Materials Sciences</td></tr>
<tr><td colspan="3">Elective Modules in General Competences
(9 Modules, Selection of 5 ECTS-Credits)</td></tr>
</table>