This translation is only for general information and must not be used in connection with any legal proceedings. Only the original German version is legally binding.

TECHNISCHE UNIVERSITÄT ILMENAU

Academic Regulations
for the
major in Micro- and Nanotechnologies
with the degree "Master of Science"

According to § 3 par. 1 in conjunction with § 34 par. 3 of the Thüringer Hochschulgesetz (Thuringian University Act, ThürHG) dated 21 December 2006 (GVBl, page 601) last amended by Art. 12 of the Act dated 12 August 2014 (GVBI, page 472) and based on the Examination Regulations – General Provisions – for study courses in Bachelor and Master's degree programs (PO-AB) as published in the Verkündungsblatt (Official Journal of the university) No. 115/2013, in the respective current version, and the Examination Regulations – Special Provisions – (MPO-BB) for the major in Micro- and Nanotechnologies as published in Verkündungsblatt (Official Journal) of the university No. 150/2016, in the respective current version, the Technische Universität Ilmenau (hereinafter referred to as "university") has enacted the following Academic Regulations for the major in Micro- and Nanotechnologies with the final degree "Master of Science".

The Departmental Council of the Department of Electrical Engineering and Information Technology approved these Regulations on 09 February 2016. The Senate of the TU Ilmenau supported these Regulations on 05 April 2016. The University's President approved and authorized the document on 09 May 2016. The regulations were submitted to the Ministry for Economic Affairs, Science and Digital Society of the Free State of Thuringia in a letter dated 11 May 2016.

Table of contents

§ 1 Scope of the Regulations

(1) Based on the Examination Regulations – General Provisions – for majors with the final degree "Bachelor" or "Master" (PO-AB), published in the Verkündungsblatt (Official Journal of the university) No. 115/2013 and the respective current version, and the Examination Regulations – Special Provisions – (PO-BB) for the major in Micro- and Nanotechnologies, the Academic Regulations (StO) define the content, aims, structure and organization of the studies.

(2) All references to people and roles in these regulations apply equally to men and women.

§ 2 Standard length of study, profile type

(1) The curriculum provided in Annex 1 is part of these regulations and has been arranged in such a way that the degree course with all its examinations, pass-fail certificates and the included master thesis can be completed in the standard course length of four semesters.

(2) According to the criteria set by the Accreditation Council, the profile type of the major is "with strong emphasis on research".

§ 3 Admission requirements

Apart from the general admission requirements for a Master's program according to the Thuringian University Act, the special admission requirements for this program set forth in Annex 2 also apply.

§ 4 Aims of the program, occupational areas

The aim of the major in "Micro- and Nanotechnologies" is the education of graduates with specialized expertise in Micro- and Nanotechnologies, including special systems engineering knowledge in the fields of Mechanics, Electrical Engineering, Physics and Materials Engineering. Graduates are able to develop engineering-oriented, mathematical and natural science-based methods for formulating and solving complex problems issues in research and development and for designing, using and operating miniaturized components. This approach also covers development work in industrial companies within the fields of electronic engineering, microsystems technology, sensor and equipment technology. Graduates will also have the opportunity to work in research centers and institutes and will be able to look critically at methods and solutions, as well as to further develop given approaches. Qualification goals and the appropriate need for skilled workforce in this field are mentioned in Annex 3.

§ 5 Content and structure of the program, curriculum

(1) This course program covers a total of 120 ETCS and consists of individual modules. A module consists of one or more lecturing assignments that are coordinated in terms of content and time and are to be understood as a single teaching unit. Each individual module contains the mediation and development of the subject areas and the appropriate competences and skills. All modules are listed in the module handbook. One module can cover the content of an entire semester or can be spread over several semesters. Following the sequence of modules mentioned in the curriculum is recommended.

(2) The curriculum is described in detail in the Annex Profile Description.

(3) Students in a Double Degree Program as part of a cooperation with a partner university may complete curriculum components at the partner university according to the cooperation agreement in question. These curriculum components might differ from the Profile Description in the Annex.

(4) Apart from the subject-related modules and additionally to the required scope of lectures, students are recommended to also attend lectures and classes in the fields of business administration, law, labour and media sciences, General Studies, European Studies and foreign languages.

(5) The students are invited to support and contribute to the university's autonomous committees.

§ 6 Teaching and learning methods

The major organizational forms of the course are lectures, tutorials, practical training, seminars, a projects seminar and a research project. These organizational forms are described as follows:

- Lecture
  Coherent description and presentation of the syllabus including subject-specific techniques, methods and approaches presented by the lecturer. It is expected that students subsequently and individually work on the topic of the lectures with the help of textbooks and specific literature.

- Tutorial
  Consolidation and deepening of specific knowledge and skills by solving lecture-related tasks and exercises.

- Practical training
  Application of specific methods and approaches when conducting tests, experiments and measurements and when working on scientific papers regarding test records and measurement reports.

- Research project (*Project with seminar*)
  Within the scope of a research project students work on current research topics which refer to the Groups involved in the major. Special emphasis lies on planning and realising projects in team work with the supervising professor and other teaching staff members. Independent special literature research, based on current publications and reports concerning individual aspects of the topic in question will allow an even further improvement of presentation techniques and skills of the students. Finally, evaluation and documentation of the project results will be scientifically published.

This overview of organizational forms does not exclude other forms of teaching or a combination of several forms, e.g. the integration of field trips in seminars or exercises.

§ 7 Counselling and academic advice

(1) The Department of Electrical Engineering and Information Technology appoints an academic advisor.

(2) The academic advisor and the Division for Education of the Department of Electrical Engineering and Information Technology advise students individually.

§ 8 Coming into force of the Regulations, validity

The Academic Regulations come into force on the day they are published in the Verkündungsblatt (Official Journal of the university). The Regulations are valid for all students starting their major with the winter semester 2016/17.

Ilmenau, 09 May 2016

signed by the University's President
Univ.-Prof. Dr. rer. nat. habil.
Dr. h.c. Prof. h.c. Peter Scharff

Annex 1: Curriculum
Annex 2: Admission requirements
Annex 3: Profile description

Annex 1: Curriculum

Anlage: Studienplan

Module / Fächer	Modul-/ Fachart	Abschlussverpflichtung (Form und Dauer der PL ist im Modulhandbuch definiert)		Gewicht	Fachsemester 1. WS LP	2. SS LP	3. WS LP	4. SS LP	Summe LP
Electronics Technology 1	**P**	**MP**		**6**	**6**				**6**
Semiconductor devices 1	**P**	**MP**		**5**	**5**				**5**
Materials of Micro- and Nanotechnologies	**P**	**MP**		**5**	**5**				**5**
Nanodiagnostics	**P**	**MP**	**= zugeordnete PL**	**5**					**5**
Spectroscopic methods	P		PL		3				
Nanodiagnostics - Seminar and Practical course	P		Sb		2				
Nanotechnology	**P**	**MP**		**5**	**5**				**5**
Micro Technologies 2	**P**	**MP**		**5**		**5**			**5**
Laboratory for Materials & Micro/Nanofabrication	**P**			**5**					**5**
Laboratory for Nanomaterials	P		Sb			2			
Micro/Nanofabrication Laboratory	P		Sb			3			
Introduction to Project work / Soft skills	**P**	**MP**	**= zugeordnete PL**	**5**					**9**
Introduction to scientific work	P		Sb			2			
Introduction to advanced research	P		PL			3			
Soft skills*	P		Sb		4				
Project with seminar	**P**	**MP**		**10**			**10**		**10**
Advanced Studies (Choice of subjects according to the current catalogue)	**P**	**MP**	**= zugeordnete PL**	**30**		**15**	**15**		**30**
Technical elective subject(s) (Choice of technical subject(s) from the master curricula of the TU Ilmenau)	**P**	**MP**	**= zugeordnete PL**	**5**			**5**		**5**
Master thesis incl. colloquium	**P**	**MP**	**= zugeordnete PL**	**30**				**30**	**30**
Master thesis	P		PL						
Colloquium	P		PL						
Summe der LP					**30**	**30**	**30**	**30**	**120**

*Choice from the non-technical subject catalogue of the TU Ilmenau.

International students choose at least one course from the language institute catalogue for "Allgemeinsprache DaF"

MP	Modulprüfung	LP	Leistungspunkte
PL	Prüfungsleistung	P	Pflichtmodul
Sb	benotete Studienleistung	WP	Wahlpflichtmodul
S	unbenotete Studienleistung	W	Wahlmodul

Annex 2: Admission requirements

Admission requirements for the Master's program Micro- and Nanotechnologies

(1) The general rules and regulations for admission to Master's programs at TU Ilmenau apply here also.

(2) Admission to the Master's program of Micro- and Nanotechnologies, assuming the general admission requirements have already been fulfilled, depends on the successful completion of the aptitude test. This aptitude test determines whether an applicant meet the particular technical requirements of the Master's program of Micro- and Nanotechnologies.

(3) The Master's program requires specific knowledge in the following fields:
- Basics in materials engineering
- Higher Mathematics
- Experimental Physics/Theoretical Physics/Solid-state Physics
- Basics of electrical engineering
- Basic mechanics/engineering mechanics/mechatronics

(4) The Master's program requires knowledge of the English language at least to the level of C1, which must be proven by submitting an international certificate of one of the hereinafter mentioned tests or any other equivalent internationally accredited test:
a) TOEFL (Test of English as a Foreign Language): paper-based (ITP) min. score 550, computer-based (CBT) min. score 213 or internet-based (IBT) min. score 79
b) IELTS (International English Language Testing System): min. score 6.5
c) APIEL (Advanced Placement International English Language Examination): min. score 3
d) CEFR (Common European Framework of Reference for Languages): C1
e) Cambridge Exam: CAE (Certificate of Advanced English) or CPE (Cambridge English Proficiency)

(5) The aptitude test serves as proof of the specific technical qualification of the applicant with the help of a combination of weighted characteristics mentioned in paragraphs 6 to 8 and expressed with a score of the weighted characteristics. The applicant must achieve a minimum score of 70 in order to pass the aptitude test successfully.

(6) According to § 60 para. 1 No. 4 of the Thuringian Higher Education Act (ThürHG), the academic degree of previous BA studies is considered as follows:
a) 40 points for near-equivalent BA majors, e.g. engineering sciences with in-depth knowledge in the fields of Micro- and Nanotechnologies, Microsystems Technology or similar
b) 30 points for closely-related BA majors, e.g. Electrical Engineering and Information Technology, Mechanical Engineering, Mechatronics or similar, without specific in-depth knowledge
c) 20 points for any other BA majors, e.g. other engineering sciences or natural sciences

If necessary, the examination board will classify the majors by assessing the appropriate academic regulations.

Additionally, the final grade of the previously-achieved Bachelor degree is scored as follows:

a) very good = 30 points
b) good = 20 points
c) satisfactory = 10 points.

(7) If a final grade of "good" or "very good" has been achieved in the following three major-related subject groups or equivalent subject groups:

a) Basic knowledge and skills in electrical engineering,
b) Experimental Physics/Theoretical Physics/Solid-state Physics,
c) Basics in material technology/materials engineering,

and the grade of the Bachelor thesis or any other equivalent final paper has been awarded a mark of at least "good" as well as there being proof of qualified work experience of at least one year, these results will be considered and evaluated with 5 points each, totalling a maximum of 20 points.

(8) Should the applicant not achieve the total score, but has gained at least 50 points, his/her suitability to the course shall be determined by way of an oral examination lasting 30 minutes. This oral examination will evaluate the existing specialised knowledge referenced in parag. 3 and any professional experience. The maximum score awarded in this examination is 20 points.

(9) Any doubts or discrepencies relating to the assessment procedure are decided solely by the examination board.

Annex 3: Profile description

1. Qualification profile of the master program Micro- and Nanotechnologies

Studying Micro- and Nanotechnologies at the TU Ilmenau offers in its concept a combination of classical micro-technologies and modern nano-technologies; covering and providing methods, tools and theoretical considerations for dealing with the world of micro- and nano-scale structures. The micro-technological aspect with structural dimensions ranging from 0.1 to 1000 µm is complemented by the nano-scale world with structural dimensions of less than 100 nm. The necessity of the major arises from the fact that traditional micro-technologies have reached the limit of their classical approach to the production, testing and application of structural components with progressing miniaturization at nano levels. Thus, entirely new properties and functions are achieved at a nano scale, which offer a large application potential. Due to decreasing structural dimensions in the "nano world", the traditional disciplines of electrical engineering, natural sciences, material sciences and mechanics are being combined ever more in an integrated use of physical and chemical properties and principles.

This engineering degree program aims to teach natural scientific fundamentals and basic technical knowledge for micro- and nanostructures, as well as their systematic integration. During this degree program, students are equipped to contribute to and forward the development of micro- and nanotechnologies and their applications in the future. Particular attention is devoted to teaching equally the relevant methodical range for lithographic nanostructuring (top-down strategy); the molecular structuring through self-assembling (bottom-up approach); the opportunity of combining both concepts and the required characterization techniques also. Additional to the general basic knowledge in engineering and natural sciences, knowledge in thin-film technology, micro-structure technology and solid-state physics is provided.

This Master of Science degree program as a consecutive, research-oriented university course is based on the Bachelor of Science degree programs of Electrical Engineering, Micro-systems Engineering, Mechatronics, Technical Physics, Materials Science and similar (international) study courses, as well as optional appropriate professional experience. Due to a strong commitment to research, and with the aim of preparing students for research work in companies or at universities and attracting suitable candidates from Germany and abroad, this major is set to be designed internationally and is therefore taught in English.

<u>Qualification objectives of the major</u>

1. Graduates have already met the qualification objectives of the previous bachelor program and have now improved their skills over the course of the Master's program, achieving a higher level of confidence in applying and implementing their competencies when creating micro- and nano-structures, using these structures in components and devices and enlarging natural-scientific requirements for their preparation and functions.
2. Graduates have gained in-depth expertise in the field of Micro- and Nanotechnologies including the specialist knowledge required as a result, within the fields of Mechanics, Electrical Engineering, Physics, Materials Science and Systems Technology.

3. Graduates are able to use, critically consider and develop scientific-engineering, mathematical and natural-scientific methods for defining and solving complex problems and situations in research and development with an aim of creating, manufacturing, using and implementing of miniaturized components. The graduates are able to support development work and efforts in industrial firms in the sectors of electronic engineering, microsystems technology and sensor and instrument engineering, as well as to work in research centers and institutes.
4. The specialist expertise of the graduates is of tremendous breadth and depth and therefore the graduates can easily and independently become acquainted with both new developments in micro- and nanotechnologies and the related fields like Technical Physics, Micro- and Nano-electronic Systems and Sensor Technology.
5. Graduates have soft skills that prepare them specifically for managerial positions and tasks: ability to work in a team, communication skills, international and cultural experience, social, ecological and ethical awareness etc.
6. Graduates are able to develop innovative concepts and solutions referring to basic questions in Micro- and Nanotechnologies, also including other disciplines.
7. Graduates are able to carry out scientific work in the field of Micro- and Nanotechnologies, with an aim to continue on to doctoral studies.
8. Graduates are able to set up, manage and supervise projects in research and development in the field of Micro- and Nanotechnologies, as well as in related fields.

2. Focal points of the degree course Micro- and Nanotechnologies

The focus of the Micro- and Nanotechnologies degree course is, on the one hand, an interdisciplinary orientation ranging from natural scientific basics to engineering science-oriented application and, on the other hand, the systematic integration of methods, procedures and technologies. Micro- or nano-integration, as well as methods for a targeted generation and functionalization of firmly-established nano-structures in a technical micro-system cover one key area of research at the inter-faculty Institute for Micro- and Nanotechnologies, MacroNano®. It is in this way that the link to the scientific infrastructure in the Center for Micro- and Nanotechnologies is formed; this also represents the unique selling point of the Institute, characterizing essential contents of the major in Micro- and Nanotechnologies.

The course of study covers a tailored selection of compulsory key subjects; a range of complementary, obligatory-chosen lectures and seminars; limited internships and practical training units and an ambitious research project, which, all in all, lead to an interdisciplinary-oriented, practical education. This range of courses shall, firstly, introduce modern theories and techniques of nano-sciences, which provide the basis for Micro- and Nanotechnologies, and shall, secondly, train skills in using scientific research work to put new findings and development work into practice due to the close link to research at the TU Ilmenau. The curriculum contains the following topics:

- Nanotechnology, Nanoelectronics and Nanosensor Technology
- Materials for Micro- and Nanotechnologies
- Technologies for Micro- und Nanostructuring

- Structure and Materials testing/characterization
- Semiconductor components
- Microsystems technology/Systems integration
- Microelectronic installation and connection technology /Integrated cicuit packaging

The research-oriented and engineering degree program of "Micro- and Nanotechnologies“ is completed upon graduation with the title of "Master of Science“ jointly provided by the Departments of Electrical Engineering and Information Technology, Mechanical Engineering and Mathematics and Natural Science. The major is consecutive and students can start the program after graduating from a 6 or 7 semester Bachelor program.

The major is completed by submitting a Master thesis.

3. Demand for graduates in industry

Micro- and Nanotechnologies are key technologies at present and will continue to be in the future. The development of nanoscale materials and components, as well as their integration in micro-systems, has caused a significant demand for professionals who are able to work at the interface between the well-honed lithographic microtechnology and molecular techniques. These professionals need a solid university education containing parts of the engineering sciences and modern expertise in the fields of all natural sciences. This demand is sure to increase considerably in the years to come. The course offered here helps to close the gap between the requirements of the labour market and the offer of qualified experts.

In Thuringia, the micro-nano integration is, for example, regarded as a key technology for the qualitative leap in the field of sensor technology1. Due to the enormous potential for miniaturization, cost reduction and entirely new functionality, the micro-nano integration is considered an "Enabling Technology“ worldwide, which offers sophisticated solutions for tasks in many aspects of life, e.g. in ultra-efficient energy storage and conversion; in medical diagnostics; in environmental sensor systems; in communications or in production monitoring and control. Further details about the importance of micro-nano integration for Germany as a business location are summarized in a report on trends published by VDE and VDI2. The nation-wide demand is also clear to see in Thuringia, since employers and company representatives lament the lack of qualified micro-engineers. In Thuringia, there is an urgent need of engineers, especially in the fields of microelectronics and sensor technology.

There are very interesting employment opportunities in research centers and institutes and, above all, in the electronics industry; the sector for micro-systems technology; in the equipment industry and in material development. Due to their interdisciplinary education, graduates will find a wide range of employment opportunities in areas with close links to micro-systems technology and nano-technology, as well as in traditional fields of research and development.

1 Potentialanalyse Mikro-Nano-Integration in Thüringen, 2013.

2 http://www.mikronanotechnik.de/fileadmin/template/userfiles/pdf/VDE_-_Trendbericht_MNI.pdf

Therefore, graduates will be able to operate very flexibly in the labour market when seeking employment.

The professional career prospects for graduates of the major in Micro- and Nanotechnologies at the TU Ilmenau can be described as outstanding nationally and internationally in the mid and long term. The main areas of employment for graduates are, among others:

- Microelectronics and semiconductor industry
- Microsystems technology (MEMS/NEMS-industry)
- Smart measuring and sensor technology
- Industrial automation and control technology/process engineering
- Power engineering (esp. renewable energy generation)
- Medical technology
- Information and communications electronics