HOCHSCHULE MITTWEIDA
UNIVERSITY OF APPLIED SCIENCES

Fakultät Ingenieurwissenschaften

Module manual

of the Master's degree course

Laser Technology

March 2017

Contents

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Solid State Physics**	ECTS Credits	**5**
Short form *- Kürzel*	2901	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	The experimental and theoretical principles of solid state physics are taught. The students get an understanding of solid state phenomena as well as their theoretical foundations and are enabled to analyse and solve selected problems. Importance is also attached to the further promotion of the physical way of thinking, the presentation of factual knowledge and the furtherance of the abilities to apply the acquired knowledge for solving practical problems. The students are enabled to apply solid state physics in research and development.		
Content *- Lehrinhalte*	Structure of solids – ideal crystals and real structure; Electrons in solids – quantum mechanical models of quasi free electrons and electrons in the lattice periodic potential, energy bands and occupancy of the energy states in the bands with electrons, distinction of conductors, semiconductors and insulators, properties and dynamics of the lattice electrons; Lattice dynamics – lattice vibrations and phonons, one-dimensional calculation of the lattice vibrations; Specific heat capacity – the model of Debye; Heat conduction by phonons and by free electrons in metals; Metals und metallic alloys – state of matter diagrams, electrical conductivity and superconductivity; Semiconductors – energy band model and statistics of the free charge carriers in intrinsic and extrinsic semiconductors, the p/n-junction in equilibrium and non-equilibrium, metal-semiconductor-contacts, photo effects; Insulators – theoretical foundation of dielectric properties, mechanisms of electrical conduction and dielectric breakdown; Magnetic properties of solids; Optical properties of solids - optical quantities and fundamentals of the classic theory, dispersion in metals, semiconductors and molecular as well as ionic crystals.		
Methods *- Lernmethoden*	The course contents are dealt with in lectures, reworked by the students in self-study and deepened by solving selected problems in seminars. Furthermore, examples of the application of the acquired knowledge in praxis are discussed.		
Lectures responsible *- Dozententeam*	Prof. Dr. rer. nat. Steffen Weissmantel		
Admission *- Teilnahmevoraus-setzung*	Ready-to-use knowledge from the bachelor courses Mechanics, Fluid Mechanics / Vibrations and Waves, Technical Optics, Thermodynamics / Electricity, Structure of Matter, Mathematics I, Differential equations.		

<table>
<tr><td>Workload
- Arbeitslast</td><td>150 h totally, thereof
60 h lectures and seminars
90 h preparation and follow-up of the courses, preparation and implementation of examinations</td></tr>
<tr><td>Mode of teaching
- Lehreinheitsformen

and

Examination
- Prüfungen</td><td>
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- Lehreinheiten</th><th colspan="3">SWS</th><th rowspan="2">Prere-quisite</th><th rowspan="2">Type of examination / du-ration</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>S</th><th>I</th></tr>
<tr><td>Solid State Physics</td><td>3</td><td>1</td><td></td><td></td><td>Oral / 30 min</td><td>5</td></tr>
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</td></tr>
<tr><td>Literature
- empf. Literatur</td><td>Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik, J. H. Barth Verlag Heidelberg 1995 (Neuauflage), ISBN 3-335-00421-3.
Kittel. C.: Introduction to Solid State Physics, John Wiley and Sons Ltd, ISBN-10: 047141526X, ISBN-13: 978-0471415268.
Kopitzki, K., Einführung in die Festkörperphysik, Vieweg und Teubner Verlag 2007, ISBN-10: 3835101447, ISBN-13: 978-3835101449.</td></tr>
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Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name - Modulname	**Quantum Mechanics and Statistical Physics**	ECTS Credits	**5**
Short form *- Kürzel*	2902	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	In the course, the fundamental principles of quantum mechanics and statistical physics are imparted. Main objectives are to explain the mathematics involved, to calculate various problems and to show how many physical phenomena can be understood on that basis. Students are enabled to apply quantum mechanics for treating various problems of the atomic structure of matter as well as radiative transitions. Moreover, they will be able to use the laws of statistical physics including quantum statistics for the treatment of thermodynamical processes, phase transformations, chemical reactions and solid state physical phenomena.		

<table>
<tr><td>Content - Lehrinhalte</td><td>The failure of classical physics and the quantization of physical quantities; principles of the quantum mechanical formalism, the Hilbert-space; the probability character of quantum mechanics and the correspondence principle; Heisenberg´s Uncertainty Principle; matter waves and wave packets; the Schrödinger equation; particles in a potential well; tunnelling of particles through a potential barrier; the harmonic oscillator; the rigid rotator; angular momentum and spin; the electron shell of the atoms; perturbation theory; absorption and emission of photons.
Principles of statistical physics, thermodynamical quantities, entropy and thermodynamical probability, kinetic theory of gases, partition function and Boltzmann´s distribution function, thermodynamical potentials, molar heat capacity - Einstein and Debye-model, chemical reactions, equation of heat conduction, Fermi-Dirac-distribution, Bose-Einstein-distribution, electrons and phonons in solids.</td></tr>
<tr><td>Methods
- Lernmethoden</td><td>The course contents are dealt with in lectures, reworked by the students in self-study and deepened by solving selected problems in seminars. Furthermore, examples of the application of the acquired knowledge for the explanation and understanding of physical phenomena are discussed.</td></tr>
<tr><td>Lectures
responsible
- Dozententeam</td><td>Prof. Dr. rer. nat. Steffen Weissmantel, Prof. Dr. rer. nat. Andreas Fischer</td></tr>
<tr><td>Admission
- Teilnahmevoraus-setzung</td><td>Ready-to-use knowledge from the bachelor courses Mechanics, Fluid Mechanics / Vibrations and Waves, Technical Optics, Thermodynamics / Electricity, Structure of Matter, Mathematics I, Analysis, Probability Calculus / Statistics, Differential Equations.</td></tr>
<tr><td>Workload
- Arbeitslast</td><td>150 h totally, thereof
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<tr><td>Literature
- empf. Literatur</td><td>Feynman/Leighton/Sands, Feynman Vorlesungen über Physik, Band III: Quantenmechanik, Oldenburg Wissenschaftsverlag 2009 (Neuauflage), ISBN-10: 348658989X, ISBN-13: 978-3486589894.
Joos, G., Fricke, B., Schäfer, K., Lehrbuch der Theoretischen Physik, AU-LA – Verlag Wiesbaden, ISBN-10: 3891044623, ISBN-13: 978-3891044629.
Fliessbach, T., Quantenmechanik: Lehrbuch zur Theoretischen Physik III, Spektrum-Akademischer Verlag 2008 (5. Auflage), ISBN-10: 3827420202,
ISBN-13: 978-3827420206.
Fliessbach, T., Statistische Physik: Lehrbuch zur Theoretischen Physik IV, Spektrum-Akademischer Verlag 2010 (5. Auflage), ISBN-10: 3827425271,
ISBN-13: 978-3827425270.
Reichl, L.E., A Modern Course in Statistical Physics, Verlag J. Wiley.
Diu, .,Guthmann, C., Lederer, D., Roulet, B., Grundlagen der Statistischen Physik, Verlag Walter de Gruyter, ISBN 3-11-013593-0</td></tr>
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<table>
<tr><td>Studiengang - course</td><td>Laser Technology</td><td>Abschluss - degree</td><td>MSc.</td></tr>
<tr><td>Modulname - module name</td><td>Modelling/ Simulation</td><td>ECTS Credits</td><td>5</td></tr>
<tr><td>Kürzel - short form</td><td>2906</td><td>Semester - semester</td><td>WS</td></tr>
<tr><td>Pflicht/Wahl-Modul - obligatory/optional</td><td>obligatory</td><td>Häufigkeit -frequency</td><td>annually</td></tr>
<tr><td>Unterrichtssprache - teaching language</td><td>deutsch or english</td><td>Dauer - duration</td><td>1 semester</td></tr>
<tr><td>Ausbildungsziele - objectives</td><td colspan="3">The module provides methodological and technical competence for the modeling and simulation of physical processes. The students are enabled to model physical processes and technologies on selected examples and to program them using appropriate software. In particular, the assumptions have to be discussed critically. The simulation is performed by appropriate mathematical methods. MATLAB and COMSOL will mainly be applied.</td></tr>
<tr><td>Lehrinhalte - content</td><td colspan="3">Modeling of physical processes: modeling, assumptions, neglect, selection of a mathematical method
Simulation: programming of the model, execution of test calculations, presentation and discussion of the results
Application of simulation and modeling software to Processing of complex processes</td></tr>
<tr><td>Lernmethoden - methods</td><td colspan="3">Methodology of the seminar, Procedures and techniques, as well as a reasonable Theory-oriented presentation and discussion of problems. Presence teaching is structured in knowledge modules CBT (Computer Based training) and LBD (Learning by Doing) Application.</td></tr>
<tr><td>Dozententeam verantwortlich - lecturers</td><td colspan="3">Prof. Dr. rer.nat. A. Fischer</td></tr>
<tr><td>Teilnahme-voraussetzungen - admission</td><td colspan="3">Knowledge in programming</td></tr>
<tr><td>Arbeitslast - workload</td><td colspan="3">30 h lecture, 15 h seminar, 30 h Internship,
Further 75 h are planned for self-study, programming and preparation of the project work.</td></tr>
<tr><td>Lehreinheitsformen – mode of teaching
und
Prüfungen - examination</td><td colspan="3">
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<tr><th>Lehreinheiten - units</th><th colspan="3">SWS</th><th>PVL</th><th>Prüfungsleistungen/Wich-tung/Dauer</th><th>Credits</th></tr>
<tr><th></th><th>V</th><th>S</th><th>P</th><th></th><th></th><th></th></tr>
<tr><td>Simulation physik. Prozesse</td><td>2</td><td>1</td><td></td><td></td><td>Ms/PA</td><td>5</td></tr>
<tr><td>Praktikum</td><td></td><td></td><td>2</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Empf. Literatur - literature</td><td colspan="3">Grupp F.: MATLAB für Ingenieure Grundlagen und Programmbeispiele. Oldenburg Verlag München
Bode, H.: MATLAB in der Regelungstechnik. B.G. Teubner Stuttgart
Taubert K., Wiedl W.,: MATLAB. Universität Hamburg
Benker, H.: Mathematik mit MATLAB, Eine Einführung für Ingenieure und Naturwissenschaftler, Springer Verlag Heidelberg</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Laser device technology**	ECTS Credits	**5**
Short form - *Kürzel*	2904	Semester - *Semester*	WS
Obligatory/optional - *Pflicht/Wahl-Modul*	obligatory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester
Objectives - *Ausbildungsziele*	Building up on the modules laser material treatment and device technology of the bachelor's course of studies laser technology acquires of the studying competence to constructive aspects of the component to be worked on with the laser as well as also to the laser-beam analysis. He is able to characterise laser beams extensively. He has applied his theoretical knowledge in the training period and has deepened. He can analyse well-chosen components of the laser devices from the point of the laser construction and laser development and compare the newest realised laser. In particular, the students have acquired knowledge in the development of laser diodes and diode lasers and their use as a pumping laser source or independent laser and can evaluate and use laser process control as a quality assurance method during laser processing in production.		

Content - *Lehrinhalte*	Construction appropriate for laser (Weld, reaping, soldering) Laser-beam diagnosis Economic considerations (project work) Laser diodes and high-capacity diode lasers Diode-pumped solid state lasers (stick laser, Slablaser, disc laser) Fiber laser - practical construction, functionality, qualities Gas laser for the material treatment Confrontation of the single laser draughts Problems of the electricity supply of diode lasers Diode-pumped solid state laser – constructive aspects Laser process control Laser training period: Laser-beam diagnosis, fiber laser
Methods - *Lernmethoden*	The teaching contents are presented in the lectures, and are discussed in the kind of seminarist's broads of lessons constantly with the students. Besides, the application possibilities of the acquired knowledge are also discussed in practice. Material contents are to be made up by the students in the self-study. Within the scope of a project work in groups, the discussion economic aspects of the laser application is prepared.
Lectures responsible - *Dozententeam*	Prof. Dr.-Ing. Horst Exner
Admission - *Teilnahmevoraus-setzung*	Lecture course physics, waving optics, structure of the matter, mathematics, differential equations, laser physics, solid state physics, material customer, electronics materials, parts of the laser device technology and laser material treatment
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and seminars 90 h preparation and follow-up of the courses, test preparation and implementation

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<tr><th>Units
- Lehreinheiten</th><th colspan="3">SWS
L S I</th><th>Prere-quisite</th><th>test performan-ce/
weightning/du-ration</th><th>Credits</th></tr>
<tr><td>Laser device technology</td><td>2</td><td>1</td><td>1</td><td>LT</td><td>oral/30</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Literature
- empf. Literatur</td><td>Meschede, D.: Optik, Licht und Laser, Vieweg und Teubner 1999, 2005, 2008, ISBN 978-3-8351-0143-2.
Iffländer, Reinhard: Festkörperlaser zur Materialbearbeitung
Berlin, Heidelberg, Springer Verlag (Laser in Technik und Forschung)
ISBN 3-540-52150-X (Berlin)
Helmut Hügel, Thomas Graf: Laser in der Fertigung,
Zweite neu bearbeitete Auflage, Wiesbaden, Springer Verlag 2009</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Radiation physics/ optics**	ECTS Credits	**5**
Short form - *Kürzel*	2905	Semester - *Semester*	WS
Obligatory/optional - *Pflicht/Wahl-Modul*	electory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester

Objectives - *Ausbildungsziele*	The students, in particular the graduates of the classical engineer's courses of studies, attain building up on the physics and optics knowledge acquired in the bachelor's course of studies connection with the knowledge presumed in the master course of studies in the area of the production and propagation from electromagnetic waves as well as the interaction of this radiation with matter. They understand the quantum-mechanical principles of the issue and absorption process. They can describe the wave-optical phenomena (interference, declension, polarisation) by the propagation of the laser beams qualitatively and quantitatively. It concerns a construction module.
Content - *Lehrinhalte*	Maxwell's equations, dipole radiation, Planck's radiation law, Wave-particle dualism, atomic numbers, quantum numbers and spectroscopic notation of atoms, L-S coupling Electromagnetic radiation, properties and effect of laser beams, Optics: propagation of light, Fermat's principle, reflection, refraction, paraxial rays, images with lenses and lens systems, Huygens-Fresnel principle, interference, diffraction, polarization, dispersion, absorption
Methods - *Lernmethoden*	The contents of the lectures are presented in the lectures, reworked by the students in self-study and deepened by solving the tasks in the seminar. The basic principles of electromagnetic radiation, laser radiation and optics, which are essential for laser technology, are presented in particular.
Lectures <u>responsible</u> - *Dozententeam*	Prof. Dr. rer. nat Andreas Fischer, Prof. Dr. rer. nat. Bernhard Steiger
Admission - *Teilnahmevoraus-setzung*	Knowledge of classical physics
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and seminars 90 h preparation and follow-up of the courses, test preparation and implementation

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<tr><td>Units
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weightning/du-ration</td><td>Credits</td></tr>
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<tr><td>Literature

- empf. Literatur</td><td>Hering, E., Martin R., Stohrer M.: Physik für Ingenieure.
VDI-Verlag Düsseldorf
Paus H.: Physik in Experimenten und Beispielen.
Carl Hanser Verlag München
Kneubühl/Sigrist Laser, Teubner Studienbücher Physik,
Wiesbaden
Donges, A., Physikalische Grundlagen der Lasertechnik,
Hüthig Verlag, Heidelberg
Silvast, W.T., Laser Fundamentals, Cambridge University Press,
Cambridge
Eichler/Müller: Lasertechnik in der Medizin , Springer
Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure,
Springerverlag Berlin Heidelberg, 2002
Klein, Furtak, „Optik“, Springerverlag Berlin Heidelberg 1988,</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Laser physics**	ECTS Credits	**5**
Short form - *Kürzel*	2905	Semester - *Semester*	WS

Obligatory/optional *- Pflicht/Wahl-Modul*	electory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	The students know and understand the physical principles and operating principles of the laser, the different laser types, the mathematical description of laser radiation and laser beam propagation as well as the physical operating principles of peripheral components. The students gain the necessary knowledge for the use of laser radiation for a wide range of technologies.		
Content *- Lehrinhalte*	Electromagnetic radiation and the properties and effects of laser beams; Fundamentals of the radiation theory of the laser - spontaneous and induced emission, balance equations, 1st and 2nd laser conditions and principle of action of the laser; Stable and unstable optical resonators, stability criteria; Longitudinal and transverse mode selection; Suitable term schemes for lasers; Laser types; Description and characteristics of laser radiation; Transforming a Gaussian laser beam through a thin lens; Generation of short and ultramarc laser pulses by means of active and passive excitation as well as mode coupling; Characterization of pulsed laser beams; Generation of second and third harmonics.		
Methods *- Lernmethoden*	The teaching contents are presented in the lectures, are made up by the students in the self-study and are deepened by solving of duties in the seminar. Besides, the application possibilities of the acquired knowledge and concrete examples of the practical application of the laser are also discussed and demonstration experiments are brought forward.		
Lectures responsible *- Dozententeam*	Prof. Dr. rer. nat. Steffen Weißmantel		
Admission *- Teilnahmevoraus-setzung*	Lecture series Physics: Module Mechanics, currents / waves / optics, caloric / electrics, structure of matter, mathematics I, differential equations		

<table>
<tr><td>Workload

- Arbeitslast</td><td>150 h total, thereof

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90 h preparation and follow-up of the courses, test preparation and implementation</td></tr>
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<tr><td>Components of laser technology</td><td>3</td><td>1</td><td></td><td>LT</td><td>written/30</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>Kneubühl, F.K., Sigrist, M.W.: Laser, Vieweg + Teubner Verlag 2008

(7. Auflage) ISBN 978-3-8351-0145-6.

Eichler, J.: Laser – Bauformen, Strahlführung, Anwendungen;

Springerverlag, Berlin, 2006, ISBN 3540301493.

Hügel, H.: Laser in der Fertigung – Strahlquellen,

Systeme, Fertigungsverfahren; Verlag Vieweg und Teubner,

ISBN 978-3835100053.

Graf, T.: Laser: Grundlagen der Laserstrahlquellen,

Verlag Vieweg und Teubner, 2009, ISBN 3834807702.</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Electronics digital**	ECTS Credits	**5**
Short form - *Kürzel*	2907	Semester - *Semester*	WS
Obligatory/optional - *Pflicht/Wahl-Modul*	electory	Frequency - *Häufigkeit*	annually

Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester
Objectives - *Ausbildungsziele*	In this module grounding and methods of the digital technology is given. The students can describe digital circuits, analyse or select according to the demands or sketch. By practical exercises they receive the ability and the skills digital circuits to dimension, to program, to be based, to analyse and to test.		
Content - *Lehrinhalte*	Binary logic (logical states and level recorders, definition of switch times, logical basic functions, lied. Basic fence, Boolesche algebra, putting up and optimising lied. Functions); Switching circuit families (overview, characteristics, static and dynamic behaviour of switch circuits; sequential circuits; programmable logical circuits; modelling and calculator-supported draught of digital systems, minimizing of state machines; construction, function and characteristics from D/A-and A/D converters; logic analysis.		
Methods - *Lernmethoden*	The lecture provides the theoretical bases of the construction up to the draught of digital circuits. In the seminar the theoretically provided calculations and draught methods are coached at practise examples and are strengthened. Besides, calculator-supported methods should be used. In the training period skills are given by investigation and realisation of digital circuits.		
Lectures responsible - *Dozententeam*	Prof. Dr.-Ing. Wilfried Schmalwasser Dr.-Ing. Jörg Krupke		
Admission - *Teilnahmevoraus-setzung*	Participation in the modules electrical engineering; physics of electronic construction elements; measuring technology or equivalent knowledge.		
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and seminars 90 h preparation and follow-up of the courses, test preparation and implementation		

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<tr><td>Components of laser technology</td><td>3</td><td>1</td><td>1</td><td>LT</td><td>written/30</td><td>5</td></tr>
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<tr><td>Literature

- empf. Literatur</td><td>Martin V. Künzli: Vom Gatter zu VHDL,

V/d|f – Hochschulverlag AG an der ETH Zürich

Lichtberger, B.: Praktische Digitaltechnik, Hüthig Buch Verlag</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name *- Modulname*	**Digital image processing**	ECTS Credits	**5**
Short form *- Kürzel*	2908	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	elective	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	The students acquire core competences for them in this module the digital image processing which they enable, procedures specifically to start and in the solution of complicated duties of the digital ones to help competently image processing. In this module are of use the students of foreign-language literature and compile of more complicated duties in teamwork. Their material competence and professionalism it is promoted by solving these duties.		

Content - *Lehrinhalte*	terms and definitions Image models Topological, geometric, statistical properties of images Image enhancement Segmentation methods Filter (High, Low, Bandpass) Edge operators Hough transformation, parameter transformation Ranking procedures Morphological operations Object recognition Fourier transformation Transformations in the spectral space Folds, inverse folds Image compression
Methods - *Lernmethoden*	In the lecture become concepts, notations and procedures of the digital image processing mediates. Practical tasks of image processing will be analyzed and the solutions will be prepared. By means of provided software, the students solve standard tasks independently of digital image processing.
Lectures responsible - *Dozententeam*	Prof. Dr. rer. nat. habil. Haenselmann
Admission - *Teilnahmevoraus-setzung*	Basic programming skills
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and practical training 90 h preparation and follow-up of the courses, test preparation and implementation

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<tr><td>Literature

- empf. Literatur</td><td>Vorlesungsmanuskript Tönnies, K.D.: Grundlagen der Bildverarbeitung, Pearson Studium, 2005

Zamperoni, P.: Methoden der digitalen Bildsignalverarbeitung, Braunschweig, Vieweg, 1991 Gonzales, R.C.;

Wintz, P.: Digital Image Processing, Addison-Wesley, 1987 Steinbrecher, R.: Bildverarbeitung in der Praxis, Oldenbourg, 1993

Pavlidis, T.:Algorithms for Graphics and Image Processing, Springer, 1982 Jähne, B.: Digitale Bildverarbeitung, Springer, 1991 Wahl,

F.M.:Digitale Bildverarbeitung, Springer, 1984 Pratt,

W.K.: Digital Image Processing, John Wiley & Sons, 1978 Handels, H.: Medizinische Bildverarbeitung, B.G. Teubner, 2000</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Physical Analytics**	ECTS Credits	**5**
Short form - *Kürzel*	2915	Semester - *Semester*	SS
Obligatory/optional - *Pflicht/Wahl-Modul*	obligatory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester

Objectives - *Ausbildungsziele*	The students acquire within the scope of the module knowledge to the bases, active principles and operational areas more substantially of physical analytics procedures building up in particular on the modules „structure of the matter“ and „bases of solid state physics“. The students know the physical and experimental bases of important physical analysis procedures and have attained a deep understanding of the different procedures with the help of more inevitably mathematical apparatuses. They show the necessary fact knowledge for the use of the demonstrated material. The students attain detailed competence for the application of the procedures for the clarification from
Content - *Lehrinhalte*	Physical basis of analytical procedures; Solid state analysis with X-rays and electron beams - X-ray and electron diffraction, scanning and transmission electron microscopy, electron spectroscopy, microanalysis methods; Solid state analysis with ion beams - Rutherford backscattering and secondary ion mass spectroscopy; Scanning tunneling and scanning force microscopy including derived methods; Principles and applications of infrared and Raman spectroscopy as well as UV-VIS spectroscopy; Nuclear magnetic resonance and electron spin resonance spectroscopy
Methods - *Lernmethoden*	The contents of the lectures are presented in the lectures, reworked by the students in self-study and deepened by solving the tasks in the seminar. The scope of application of the acquired knowledge is also discussed in practice.
Lectures responsible - *Dozententeam*	Prof. Dr. rer. nat. Steffen Weißmantel
Admission - *Teilnahmevoraus-setzung*	Basic physics skills
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and practical training 90 h preparation and follow-up of the courses, test preparation and implementation

<table>
<tr><td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td><td>
<table>
<tr><td>Units
- Lehreinheiten</td><td colspan="3">SWS
L | S | I</td><td>Prere-quisite</td><td>test performan-ce/

weightning/du-ration</td><td>Credits</td></tr>
<tr><td>Components of laser technology</td><td>3</td><td>1</td><td></td><td></td><td>oral/30</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik,
J. H. Barth Verlag Heidelberg 1995, ISBN 3-335-00421-3.
Demtröder, W., Laserspektroskopie 1: Grundlagen,
Springer Verlag 2011 (6. Auflage),
ISBN-10: 3642213057, ISBN-13: 978-3642213052.
Demtröder, W., Laserspektroskopie 2: Experimentelle Techniken,
Springer Verlag 2013 (6. Auflage), ISBN-10: 3642214460,
ISBN-13: 978-3642214462.
Demtröder, W., Molekülphysik: Theoretische Grundlagen und
experimentelle Methoden, Oldenbourg Wissenschaftsverlag 2003
(1. Auflage), ISBN-10: 3486249746, ISBN-13: 978-3486249743.
Göpel/Ziegler, Struktur der Materie: Grundlagen, Mikroskopie und
Spektroskopie, Teubner Verlag 1994, ISBN-10: 3815421101
ISBN-13: 978-3815421109.</td></tr>
</table>

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Physics of laser radiation / matter interaction**	ECTS Credits	**5**

<table>
<tr><td>Short form
- Kürzel</td><td>2916</td><td>Semester
- Semester</td><td>2</td></tr>
<tr><td>Obligatory/optional
- Pflicht/Wahl-Modul</td><td>obligatory</td><td>Frequency
- Häufigkeit</td><td>annually</td></tr>
<tr><td>Teaching language
- Unterrichtssprache</td><td>english</td><td>Duration
- Dauer</td><td>1 semester</td></tr>
<tr><td>Objectives
- Ausbildungsziele</td><td colspan="3">After completion of the module the students are able to understand and apply the experimental and theoretical basics of the laser radiation – material interaction. They are concerned with the optical properties of solids, the phenomena which occur during the interaction of laser radiation / photons with solids and the mathematical specification of these effects. Because of their acquired insight the students are able to understand the complex correlations of the laser radiation – material interaction and can apply this knowledge to technically relevant laser processes.</td></tr>
<tr><td>Content - Lehrinhalte</td><td colspan="3">Optical properties of solid states – optical properties and basics of classical electro dynamical theory; Fresnel coefficients; dispersion of metals, semiconductors and molecular crystals and molecular ion crystals and their interpretation; Basics of nonlinear crystal optics – Fresnel equations and optical axes, structures of crystals and optical properties, nonlinear polarization and generation of higher harmonics, phase matching in anisotropic crystals; Interaction of laser radiation with metals, semiconductors and insulators – absorption, heating and melting, evaporation and ablation with plasma imaging; ultra-short pulses of high intensity and solid state absorption with single- photon and multi-photon processes; excitation of plasmons, two-temperature model; material removal by ablation and structure formation on surfaces; pulse duration and electron phonon coupling time.</td></tr>
<tr><td>Methods
- Lernmethoden</td><td colspan="3">The contents of this module are presented in the lectures and reproduced by the students in self-study. By solving tasks the understanding will be improved and the application possibilities will be discussed.</td></tr>
<tr><td>Lectures
responsible
- Dozententeam</td><td colspan="3">Prof. Dr. rer. nat. habil. Alexander Horn,
Prof. Dr. rer. nat. Steffen Weissmantel.</td></tr>
<tr><td>Admission
- Teilnahmevoraus-setzung</td><td colspan="3">Ready-to-use knowledge from bachelor's program laser technology, physics, mathematics, technical optics, physical measurement techniques.</td></tr>
<tr><td>Workload
- Arbeitslast</td><td colspan="3">150 h total, thereof
60 h lectures and seminars
90 h preparation and follow-up of the courses, test preparation and implementation</td></tr>
<tr><td>Mode of teaching
- Lehreinheitsformen
and
Examination
- Prüfungen</td><td colspan="3">
<table>
<tr><th rowspan="2">Units
- Lehreinheiten</th><th colspan="3">SWS</th><th rowspan="2">Prere-quisite</th><th rowspan="2">test performan-ce/ weightning/du-ration</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>S</th><th>I</th></tr>
<tr><td></td><td>4</td><td></td><td></td><td></td><td>oral/30</td><td>5</td></tr>
</table>
</td></tr>
</table>

Literature *- empf. Literatur*	Hecht, E., Optics, Addison-Wesley; 4 edition, August 12, 2001 Träger, F., Handbook of Lasers and Optics, Springer-Verlag, 2012 Diehls, J.C., Ultrashort Laser Pulse Phenomena, Academic Press 1996 Brandt/Dahmen, Elektrodynamik, Springer Verlag, 2005 T. Fließbach, Elektrodynamik, Springer Verlag, 2012 Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik, J. H. Barth Verlag Heidelberg 1995 (Neuauflage) Kittel. C.: Introduction to Solid State Physics, 8th Edition, Wiley 2005 Bäuerle, D.: Laser Processing and Chemistry, Springer-Verlag 1986, 1996 Pedrotti, F et.al..: Optik für Ingenieure, Springer-Verlag 2002, 2005, 2008 Sobol, E.N.: Phase Transformations and Ablation in Laser-Treated Solids, John Wiley and Sons 1995, ISBN 0-471-59899-2. Meschede, D.: Optik, Licht und Laser, Vieweg und Teubner 1999, 2005, 2008, ISBN 978-3-8351-0143-2. Horn, A., Ultrafast Materials Metrology, Wiley-Verlag 2009

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name *- Modulname*	**Physical Coating Technologies**	ECTS Credits	**5**
Short form *- Kürzel*	2914	Semester *- Semester*	SS
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	In this module, the students learn the basics of modern, physically embossed vacuum processes for layer deposition and surface modification and understand their advantageous use by means of application examples. In this way, the students gain the competence to assess the possibilities of using thin layers as functional layers and / or for surface modification, as well as to select suitable production processes for the generation of special layers for a wide range of applications.		

Content - *Lehrinhalte*	The basic principles for the generation and characterization of vacuum are explained in an introductory way, as well as an introduction to the fundamentals of plasma physics. The various types of gas discharge and the production of ion beams are treated for this purpose. Within the context of vacuum coating processes, the physical vapor deposition (PVD) processes are presented and delineated by the CVD (Chemical Vapor Deposition) processes. These include evaporation and atomization processes, the mechanisms of action and their influence on the properties of deposited layers. The use of laser radiation both for evaporation and ablation as well as for influencing the layer properties is included. The material is supplemented by numerous practical examples from the fields of material technology and wear, optics, electronics and storage media as well as medical technology.
Methods - *Lernmethoden*	The content of the course is presented in lectures and reworked by the students. In the seminars, the tasks are solved, the solutions of which are addressed to the students. The proposed solutions will be discussed in the seminar, taking into account their advantages and disadvantages. In some practical tests coatings and / or surface modifications and the complicated technological Influences on the processes.
Lectures responsible - *Dozententeam*	Prof. Dr. rer. nat. Steffen Weißmantel
Admission - *Teilnahmevoraus-setzung*	Basic programming skills
Workload - *Arbeitslast*	150 h total, thereof 60 h lectures and practical training 90 h preparation and follow-up of the courses, test preparation and implementation

<table>
<tr>
<td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td>
<td>
<table>
<tr><th>Units
- Lehreinheiten</th><th colspan="3">SWS
L S I</th><th>Prere-quisite</th><th>test performan-ce/
weightning/du-ration</th><th>Credits</th></tr>
<tr><td>Components of laser technology</td><td>2</td><td>1</td><td>1</td><td>LT</td><td>written/90</td><td>5</td></tr>
</table>
</td>
</tr>
<tr>
<td>Literature

- empf. Literatur</td>
<td>Frey, H., Kienel, G., Behringer,U.: Dünnschichttechnologie,
VDI – Verlag 1993, ISBN-10: 3184006700, ISBN-13: 978-3184006709.
Bach, F.W., Möhwald, K., Laarmann, A., Wenz, T.:
Moderne Beschichtungsverfahren, Wiley VCH – Verlag 2004 (2. Auflage),
ISBN-10: 3527309772, ISBN-13: 978-3527309771.
Bunshah, R.F.: Handbook of Hard Coatings:
Deposition Technolgies, Properties and Applications, William Andrew
Inc. 2000, ISBN-10: 0815514387, ISBN-13: 978-0815514381.</td>
</tr>
</table>

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Components of laser technology**	ECTS Credits	**5**
Short form *- Kürzel*	2917	Semester *- Semester*	SS
Obligatory/optional *- Pflicht/Wahl-Modul*	elective	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester

Objectives *- Ausbildungsziele*	This module provides broad knowledge on selected components of laser technology based on principles of laser physics, laser technology and optics. After completing the module, the students are able to choose and to implement appropriate components inside complex systems depending on the requirements of the task. They understand the functionality and the principles of the elements for • fast laser beam switching (AOM, EOM, pockels cell) • modification of the polarization state • frequency conversion (SHG, THG, 3- and 4-wave mixing)
Content *- Lehrinhalte*	- Optical beam switches (electro-optical and acousto-optical principle) - Introduction into nonlinear optics and frequency conversion - Second harmonic generation, third harmonic generation - Three-wave mixing (sum frequency and difference frequency generation optical parametric processes) - Four-wave mixing
Methods *- Lernmethoden*	The knowledge will be imparted in a seminar-like tuition and has to be completed deepened by self-studying. Hereby, the main emphasis will be on direct reference of the teaching content for the practical application. The lecture material will be presented as Powerpoint presentation supported by content-relevant image material.
Lectures responsible *- Dozententeam*	Prof. Dr. rer. nat. B. Steiger, Prof. Dr.-Ing. U. Loeschner
Admission *- Teilnahmevoraus-setzung*	Ready-to-use knowledge from bachelor's program laser technology, physics, mathematics, technical optics, physical measurement techniques.
Workload *- Arbeitslast*	150 h total, thereof 60 h lectures and seminars 90 h preparation and follow-up of the courses, test preparation and implementation

Mode of teaching *- Lehreinheitsformen* and Examination *- Prüfungen*

Units *- Lehreinheiten*	SWS L	SWS S	SWS I	Prere-quisite	test performan-ce/ weightning/du-ration	Credits
Components of laser technology	2	1		LT	oral/30	5

Literature *- empf. Literatur*	1. Laser Jürgen Eichler, Hans Joachim Eichler Bauformen, Strahlführung, Anwendungen Springer Verlag ISBN 978-3-540-30149-3 2. Optik, Licht und Laser D. Meschede Vieweg+Teubner Verlag, 3. durchges. Aufl. 2008 ISBN-10: 3835101439 3. Lasertechnik Grundlagen und Anwendungen Helmbrecht Bauer Würzburg: Vogel,1991 (Kamprath-Reihe) ISBN 3-8023-0437-3 4. Optik für Ingenieure: Grundlagen F. Pedrotti, L. Pedrotti, W. Bausch, H. Schmidt Springer Verlag, 4. bearb. Aufl. 2008 ISBN: 3540734716 5. Bauelemente der Optik: Taschenbuch der technischen Optik H. Naumann, G. Schröder Fachbuchverlag Leipzig, 6. Auflage (22. Oktober 1992) ISBN: 3446170367

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Research and development project I**	ECTS Credits	**5**
Short form *- Kürzel*	2920	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester

<table>
<tr><td>Objectives

- Ausbildungsziele</td><td>In this module, the students acquire methodological and technical competence to solve complex technical tasks between physical bases and their engineering implementation. They expand their social competency by working on tasks in the cooperation of many stakeholders. They analyze and solve scientific project tasks and topics from companies in the region or from scientific projects at the university. They usually perform their work in the company or in the laboratory. The students are supported in this module by a project seminar of the responsible professor.</td></tr>
<tr><td>Content - Lehrinhalte</td><td>Creation of scientific papers or studies on the chosen deepening direction</td></tr>
<tr><td>Methods

- Lernmethoden</td><td>Self-employed scientific work on the chosen deepening direction, literature studies, work in the laboratory or in the company, editing of research topics, writing of scientific papers</td></tr>
<tr><td>Lectures

<u>responsible</u>

- Dozententeam</td><td>Professors of the Department of Physics</td></tr>
<tr><td>Admission

- Teilnahmevoraus-setzung</td><td>Issue of a research topic</td></tr>
<tr><td>Workload

- Arbeitslast</td><td>300 h total, of which
75 h seminars and internships
225 h literature studies, independent scientific work and the development of a research report.</td></tr>
<tr><td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td><td>
<table>
<tr><td rowspan="2">Units
- Lehreinheiten</td><td colspan="3">SWS</td><td rowspan="2">Prere-quisite</td><td rowspan="2">test performan-ce/

weightning/du-ration</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>S</td><td>I</td></tr>
<tr><td>Components of laser technology</td><td></td><td>1</td><td>4</td><td>LT</td><td>oral/30</td><td>10</td></tr>
</table>
</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>Independent selection of literature</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Project management**	ECTS Credits	**5**
Short form - *Kürzel*	2921	Semester - *Semester*	WS
Obligatory/optional - *Pflicht/Wahl-Modul*	obligatory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester
Objectives - *Ausbildungsziele*	With the completion of this module, the students master the future requirements of the increasing complexity of economic activity, which is characterized by interdisciplinary and interdisciplinary cooperation in projects with scarce resources and low budgets. The students acquire the methodological and social competency in project management and gain the ability to transfer these competences into their own project work. The students are enabled to define project goals, to organize the project organization and cooperation in overlapping project teams, to structure projects correctly, to schedule the schedule, to plan the resources and costs, and to manage the management of the project work.		
Methods - *Lernmethoden*	The lectures deal with the classification of project management into the change processes in the economy and the transfer of knowledge to the elements of the project management. These elements are subsequently placed in the overall context of the project work, thus creating the overall context for the complexity of the work in projects. The topics are presented by comprehensive information, graphics, texts, exercises and practical examples, in order to support the concrete application by the students. Complementary literature sources are intended to support the learning process. As part of the complementary exercises, the students work on a complex project case study in group work with the aim of applying all elements of the project management in their context in order to support the transfer process in their own work.		
Lectures <u>responsible</u> - *Dozententeam*	Dipl.-Psych. Frank Schumann, Wirtsch.-Ing. Matthias Baumgart		

<table>
<tr><td>Admission

- Teilnahmevoraus-setzung</td><td></td></tr>
<tr><td>Workload

- Arbeitslast</td><td>150 h total, thereof

75 h lectures and practical training

75 h preparation and follow-up of the courses, test preparation and implementation</td></tr>
<tr><td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td><td>
<table>
<tr><td>Units
- Lehreinheiten</td><td colspan="3">SWS
L | S | I</td><td>Prere-quisite</td><td>test performan-ce/

weightning/du-ration</td><td>Credits</td></tr>
<tr><td>Components of laser technology</td><td>4</td><td>1</td><td></td><td></td><td>written/120</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>KERZNER Harold, Projektmanagement –

Ein systemorientierter Ansatz zur Planung und Steuerung,

Frechen 2008, mitp Verlag

RÖßLER, MÄHLISCH, FRIEDRICH, VOIGTMANN,

Projektmanagement für Newcomer, 2008, RKW Sachsen GmbH

PATZAK Gerold, RATTAY, Günter, Projektmanagement:

Leitfaden zum Management von Projekten, Projektportfolios und

projektorientierten Unternehmen, Wien 2008, Linde Verlag

FELKAI, Roland, BEIDERWIEDEN, Arndt, Projektmanagement für

technische Projekte: Ein prozessorientierter Leitfaden für die Praxis,

Wiesbaden 2010, Vieweg+Teubner Verlag</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Modul name - *Modulename*	**Optical design/ Integrated optics**	ECTS Credits	**5**
Short form - *Kürzel*	2922	Semester - *Semester*	SS
Obligatory/optional - *Pflicht/Wahl-Modul*	compulsory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 Semester

Objectives - *Ausbildungsziele*	The module conveys expertise and methodological competence to all students at the Master programme Laser technology, primarily specializing on background of modern micro optics and the development of optical components, respectively. Students are supposed to gain knowledge about methods as well as techniques concerning the development and fabrication of optical components, clusters and complex systems. A further objective deals with the special demands on optoelectronical components with regard to miniaturisation.
Content - *Lehrinhalte*	Mainly, the objective of teaching is to understand basic operational principles of optoelectronical components, gain hands-on-experience using development software to calculate the propagation of electromagnetic waves as well as to introduce the setup and principle of complex optical systems, microoptical devices, wave guides and wave guide systems, materials for microoptical purposes and manufacturing methods in microoptics.
Methods - *Lernmethoden*	The content is presented in lectures and processed by the students in subsequent work. In the seminars special approaches are discussed more in detail. Discussions give way to analyse certain problems more precisely, helping to enable the essential by the disregard of second assumptions and boundary conditions.
*L*ecturers responsible - *Dozententeam*	Prof. Dr. rer. nat. B. Steiger
Admission - *Teilnahme-voraussetzungen*	Basic knowlege of Technical Optics
Workload - *Arbeitslast*	150 h total, thereof 75 h lectures and seminars 75 h preparation and follow-up of the courses, test preparation and implementation

Mode of teaching - *Lehreinheitsformen* and Examination - *Prüfungen*

Units - *Lehreinheiten*	SWS L	SWS S	SWS I	Prere-quisite	Test perfor-mence/ weightning/ duration	Credits
Optical design/ Integrated optics	3	2	-	-	Mm/45	5

Literature *- Empf. Literatur*	Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Springerverlag Berlin Heidelberg, 2002 Schröter, „Technische Optik“, Vogel Buchverlag, Würzburg Bergmann / Schäfer, „Lehrbuch der Experimentalphysik“, Band 8 „Optik“, Walter de Gruyter, N.Y. Ebeling, Integrierte Optoelektronik, Springerverlag Berlin Heidelberg, 1992 Hunsperger, Integrated Optics: Theory and Technology, Springerverlag Berlin Heidelberg, 1991
Application *- Verwendung*	
Comments *- Bemerkungen*	

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Micro- and Nano technology**	ECTS Credits	**5**
Short form *- Kürzel*	2923	Semester *- Semester*	3
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	After completion of the module the students master the basics of modern physically characterized micro- and nanotechnology processes. They can demonstrate the advantageous use of these processes to generate new products based on selected examples. This allows the students to estimate the modern micro- and nanotechnology processes and they are able to select and develop processes for specific applications by their own.		
Content *- Lehrinhalte*	Areas and dimensions of micro-technology, manufacturing technologies of micro-technology, conventional manufacturing methods and processes of semiconductor technology in micro-technology, LIGA technology, laser radiation-based micro-technologies, coating techniques, functional and constructional materials of micro-technology, Application examples: sensors, actuators and micro – optic construction element, micro-structured functional surfaces and layers, areas and dimensions of nano-technics, top-down and bottom-up strategies in nanotechnology, manufacturing technologies of nanotechnology, nano-chemical methods, sol-gel processes, nanomaterials, production, properties and applications of fullerenes, carbon nano-tubes, nano-fibers and nano-composites, nanostructured functional surfaces and layers, ultra-fine functional layers, nano-porous layers, self - organized nanostructures, functional nanostructures, molecular architectures, quantum effects in nanostructures, analysis of nanostructures.		
Methods *- Lernmethoden*	The contents of this module are presented in the lectures and reproduced by the students in self-study. An experimentally internships deepen the contents of the module and convey the appropriated knowledge, also exercising the scientific writing.		

<table>
<tr><td>Lectures
responsible
- Dozententeam</td><td>Prof. Dr. rer. nat. habil. Alexander Horn,
Prof. Dr. rer. nat. Steffen Weissmantel.</td></tr>
<tr><td>Admission
- Teilnahmevoraus-setzung</td><td>Ready-to-use knowledge from bachelor’s program laser technology, physics, mathematics, technical physics, physical measurement techniques.</td></tr>
<tr><td>Workload
- Arbeitslast</td><td>150 h total, thereof
60 h lectures and seminars
90 h preparation and follow-up of the courses, test preparation and implementation</td></tr>
<tr><td>Mode of teaching
- Lehreinheitsformen

and

Examination
- Prüfungen</td><td>
<table>
<tr><td>Units
- Lehreinheiten</td><td colspan="3">SWS</td><td>Prere-quisite</td><td>test performan-ce/ weightning/du-ration</td><td>Credits</td></tr>
<tr><td></td><td>L</td><td>S</td><td>I</td><td></td><td></td><td></td></tr>
<tr><td>Micro- and Nano technology</td><td>4</td><td></td><td>1</td><td></td><td>written exam /30
laboratory:
oral exam
and cerificate</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Literature
- empf. Literatur</td><td>Globisch, S., Lehrbuch “Mikrotechnologie”, Fachbuchverlag Leipzig im Carl Hanser Verlag 2011
Bharat Bhushan (Ed.), Springer Handbook of Nanotechnology, Springer Verlag 2010
Ilfrich, T., Kuhnert, G.S., Nano + Mikro I bis IV, Entwicklung der Nano- und Mikrotechnologie, Verlag: Books on Demand GmbH
Frühauf, J., Werkstoffe der Mikrotechnik, Lehrbuch für Ingenieure, Hanser Fachbuchverlag
Brück, R., Angewandte Mikrotechnik, LIGA-Laser-Feinwerktechnik, Fachbuchverlag Leipzig</td></tr>
</table>

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Current developments of laser technology**	ECTS Credits	**5**
Short form *- Kürze*	2924	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	compulsary	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester
Objectives *- Ausbildungsziele*	The module is focused on recently developed specific laser technology, largely applied in new and innovative fields of laser process developments. The students attain balanced knowledge in theory and practical application. They learn both, the laser-technical requirements and the capabilities, characteristics and limits of the technologies. The module aims to expand the student’s body of knowledge in laser technology, enabling them to transfer and apply it to further adjacent and new fields in research and developments.		

<table>
<tr><td>Content - Lehrinhalte</td><td>- simulation and experimental investigation of a laser prozess exemplified by laser bending
- ray-optical calculations: geometrical optics, wave optics, rigorous method
- new laser technologies: laser micro sintering, laser processing using fs laser radiation, laser processing inside transparent materials
- highrate laser processing: highrate-suited laser sources (fiber laser, high repetitionrate ultrashort pulse laser), highrate laser equipment (beam delivery, beam shaping, fast beam deflection systems, beam switches, motion systems, electric control), laser savety at high laser power and high brilliance, highrate laser processes (cutting, welding, microstructuring, micro sintering)</td></tr>
<tr><td>Methods
- Lernmethoden</td><td>The knowledge will be imparted in a seminar-like tuition and follows practical problems and recent scientific findings in laser research. The students will be introduced systematically to new laser material processing technologies as well as required laser machinery. The lecture material will be presented using Powerpoint. Extensive image and video material illustrate real laser processes and technologies impressively.</td></tr>
<tr><td>Lectures
responsible
- Dozententeam</td><td>Prof. Dr.-Ing. U. Loeschner</td></tr>
<tr><td>Admission
- Teilnahmevoraus-setzung</td><td>Ready-to-use knowledge from bachelor’s program laser technology, physics, mathematics, technical optics, material science, physical measurement techniques, production technology.</td></tr>
<tr><td>Workload
- Arbeitslast</td><td>150 h total, thereof
45 h lectures and seminars
105 h preparation and follow-up of the courses, test preparation and implementation</td></tr>
<tr><td>Mode of teaching
- Lehreinheitsformen

and

Examination
- Prüfungen</td><td>
<table>
<tr><td>Units
- Lehreinheiten</td><td colspan="3">SWS
L | S | I</td><td>Prere-quisite</td><td>test performan-ce/ weightning/du-ration</td><td>Credits</td></tr>
<tr><td>Current developments of laser technology</td><td>2</td><td>1</td><td></td><td></td><td>oral/30</td><td>5</td></tr>
</table>
</td></tr>
</table>

Literature *- empf. Literatur*	1. Strahlwerkzeug Laser Helmut Hügel Stuttgart Teubner -Studienbücher Verlag 1992 ISBN 3-519-06134-1 2. Laser in der Fertigung Helmut Hügel, Thomas Graf Strahlquellen, Systeme, Fertigungsverfahren Vieweg+Teubner GWV Fachverlage GmbH Wiesbaden, 2009 ISBN 978-3-8351-0005-3 3. Laser Jürgen Eichler, Hans Joachim Eichler Bauformen, Strahlführung, Anwendungen Springer Verlag ISBN 978-3-540-30149-3 4. Lasermesstechnik, Diagnostik der Kurzzeitphysik Manfred Hugenschmidt Springer Verlag ISBN 978-3-540-29920-2 5. Lasertechnik Grundlagen und Anwendungen Helmbrecht Bauer Würzburg: Vogel,1991 (Kamprath-Reihe) ISBN 3-8023-0437-3 6. Lasertechnik Dr. Hanskarl Treiber Frech-Verlag Stuttgart ISBN 3-7724-5403-8 7. Materialbearbeitung mit Lasern Dieter Bimberg Grundlagen und Anwendungen Ehningen bei Böblingen: Expert-Verl. 1991 ISBN 3-8169-0335-5

Course *- Studiengang*	Laser technology	Degree *- Abschluss*	M. Sc.
Module name *- Modulname*	**Research and development project II**	ECTS Credits	**5**
Short form *- Kürzel*	2925	Semester *- Semester*	WS
Obligatory/optional *- Pflicht/Wahl-Modul*	obligatory	Frequency *- Häufigkeit*	annually
Teaching language *- Unterrichtssprache*	english	Duration *- Dauer*	1 semester

<table>
<tr><td>Objectives

- Ausbildungsziele</td><td>With this module, the students acquire methodological and technical competence to solve complex technical tasks between physical bases and their engineering implementation. Their social competency is expanded by working together with many participants, researching topics from companies in the region or from scientific projects at the university. As a rule, the students will work in the company or the laboratory and will be supported in this module by a project seminar of the responsible professor. The students are prepared directly for the master thesis.</td></tr>
<tr><td>Content - Lehrinhalte</td><td>Creation of scientific papers or studies on the chosen deepening direction</td></tr>
<tr><td>Methods

- Lernmethoden</td><td>Self-employed scientific work on the chosen deepening direction, literature studies, work in the laboratory or in the company, editing of research topics, writing of scientific papers</td></tr>
<tr><td>Lectures

<u>responsible</u>

- Dozententeam</td><td>Professors of the Department of Physics</td></tr>
<tr><td>Admission

- Teilnahmevoraus-setzung</td><td>Issue of a research topic</td></tr>
<tr><td>Workload

- Arbeitslast</td><td>300 h total, of which
75 h seminars and internships
225 h literature studies, independent scientific work and the development of a research report.</td></tr>
<tr><td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td><td>
<table>
<tr><td>Units
- Lehreinheiten</td><td>SWS
L</td><td>S</td><td>I</td><td>Prere-quisite</td><td>test performan-ce/

weightning/du-ration</td><td>Credits</td></tr>
<tr><td>Components of laser technology</td><td></td><td>1</td><td>4</td><td></td><td>Pl4s+Pl4m</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>Independent selection of literature</td></tr>
</table>

Course - *Studiengang*	Laser technology	Degree - *Abschluss*	M. Sc.
Module name - *Modulname*	**Master project**	ECTS Credits	**5**
Short form - *Kürzel*	2926	Semester - *Semester*	SS
Obligatory/optional - *Pflicht/Wahl-Modul*	obligatory	Frequency - *Häufigkeit*	annually
Teaching language - *Unterrichtssprache*	english	Duration - *Dauer*	1 semester
Objectives - *Ausbildungsziele*	The students are enabled with this final, independent scientific work as Master of Laser Technology / Physical Technology. They apply the acquired theoretical and practical knowledge and skills, as well as overarching social competences, and provide proof of their scientific qualifications. The students prepare the master's thesis in a company, another institution or at the university. Through the final colloquium, they demonstrate their ability to present the results achieved and to discuss the issue.		
Methods - *Lernmethoden*	Seminar for the presentation of intermediate results, Independent scientific work, possibly also within the framework of a team or abroad, Qualification of scientific writing, Colloquium for the presentation and discussion of the results		
Lectures responsible - *Dozententeam*	Professors of the Department of Physics		
Admission - *Teilnahmevoraus-setzung*	Minimum of 80 credits		
Workload - *Arbeitslast*	900h total, of which 30 h for tudores		

<table>
<tr><td>Mode of teaching

- Lehreinheitsformen

and

Examination

- Prüfungen</td><td>
<table>
<tr><th>Units
- Lehreinheiten</th><th colspan="3">SWS
L | S | I</th><th>Prere-quisite</th><th>test performan-ce/

weightning/du-ration</th><th>Credits</th></tr>
<tr><td>Components of laser technology</td><td></td><td>2</td><td></td><td></td><td>written/master thesis

2/3

oral/colloquium 1/3</td><td>27 + 3</td></tr>
</table>
</td></tr>
<tr><td>Literature

- empf. Literatur</td><td>Project-related literature research by the students</td></tr>
</table>