Berner Fachhochschule

UNIVERSITÄT BERN

Master of Science
Precision Engineering

School of Biomedical and Precision Engineering

Master of Science
Precision Engineering

The Master of Science in Precision Engineering is a highly inventive and aspiring master's degree, jointly offered by the University of Bern and Bern University of Applied Sciences.

Precision Engineering looks back on a long tradition in Switzerland - and on an innovation-rich future, especially with progress of digitaliza-tion and sustainability in production.

Students are trained to become highly skilled individuals and, above that, encouraged to explore their inventive spirit and unknown, environmentally- and socially-conscious paths.

Key Features

- 120 ECTS
- 3 presence days/week at university
- International Master of Science degree in English from the University of Bern; doctoral studies accessible
- Two-year full-time program, part-time & extension possible
- Located in Bern, Switzerland

Admission

National and international students with a Bachelor of Science from a university or university of applied sciences:

- Physics
- Chemistry
- Materials Science
- Mechanical Engineering
- Electrical Engineering
- Aeronautical Engineering
- Micro(systems) Technology
- Mechatronics
- further related fields

Education

- Comprehensive knowledge and application-based scientific research
- Innovative teaching of professional and trans-lational skills

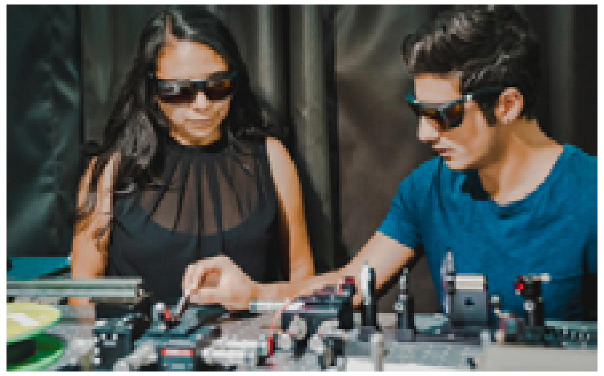
Lecturers & Mentors
from various backgrounds, including:

- University of Bern (Institute of Applied Physics, SPACE)
- Bern University of Applied Sciences
- Swiss Federal Institute of Technology Zürich
- EMPA (Swiss Federal Laboratories for Mate-rials Science and Technology)
- METAS (Federal Institute of Metrology)
- Swiss Innovation Park Biel/Bienne
- MPS Micro Precision Systems AG
- BoSonic AG
- Swiss Cluster AG
- Creaholic

Laboratories
A state-of-the-art Creative Engineering Lab with multidisciplinary scientific collaborations

- Chemical Laboratory
- Manufacturing Laboratory (with various 3D-printers, laser unit)
- Optical Laboratory (LS-LAB Micromachining System)
- Electrical Laboratory
- Mechanical Laboratory
- Research Laboratory (Swisscluster SC1, Collaborativ Robotics)

Students setting up a workplace with laser technology



Scientist working on a 3D-printed model

The new Master of Science in Precision enginee-ring focues on academic excellency and creative, interdisciplinary collaborations between students and industry.

During the master's degree, students choose the specialization of Ultraprecision Engineering or Optical Engineering and gain a comprehensive oerview, both in terms of scientific research skills and applicable professional knowledge.

Basic Courses

In the first semester, all students are required to take the six basic courses to learn new or consoli-date established knowledge, preparing for the specialization further into the studies.

Advanced Courses I & II

During the second and third semester, student select a specialization: Ultraprecision Engineering or Optical Engineering. They also build the foundation for the collaborative work in the Creative Engineering Lab. Hence, they are to be taken in the same semester or before.

Creative Engineering Lab I & II

The heart of the MSc Precision Engineering is the Creative Engineering Lab, a state-of-the-art learning and teaching facility. Here, students work in interdisciplinary groups, applying their theoretical knowledge into practice and, along-side an industry partner, bring their project to life.

Electives I & II

Out of the selection offered by the MSc Preci-sion Engineering, students choose four electives in the second and third semester to refine their portfo-lio. If desired, one elective may be chosen from listed MSc Biomedical courses.

Complementary Skills I & II

Moreover, students attend complementary skills courses and acquire additional skills and further prepare for academia, industry and entrepre-neurship.

Master Thesis

During their fourth semester, students select a topic for their master thesis, that consists of a written paper and a oral presentation.

Curriculum

Overview Full-Time Studies
Selected courses may be subject to change.

Course	Type	Semester	ECTS
Introduction to Ultraprecision Engineering	Basic Courses	1st	5 ECTS
Introduction to Optical Engineering	Basic Courses	1st	5 ECTS
Introduction to Materials and Analytics	Basic Courses	1st	5 ECTS
Physics and Structural Mechanics	Basic Courses	1st	5 ECTS
Modelling and Simulation	Basic Courses	1st	5 ECTS
Control and Automation	Basic Courses	1st	5 ECTS
Creative Engineering Lab I	Creative Engineering Lab I	2nd	12 ECTS
Advanced Courses I	Advanced Courses I	2nd	7 ECTS
Advanced Optical Design	Electives I	2nd	3 ECTS
Optics in Extreme Environments	Electives I	2nd	3 ECTS
Material Processing	Electives I	2nd	3 ECTS
Industry 4.0 and AI for Smart Production	Electives I	2nd	3 ECTS
Scientific Ethics, Writing and Presenting	Complementary Skills I	2nd	2.5 ECTS
Metrology and Sensing in Industrial Environment	Complementary Skills I	2nd	2.5 ECTS
Creative Engineering Lab II	Creative Engineering Lab II	3rd	12 ECTS
Advanced Courses II	Advanced Courses II	3rd	7 ECTS
Nano- and Micro Fabrication	Electives II	3rd	3 ECTS
In-Situ Characterisation Techniques	Electives II	3rd	3 ECTS
Heterogeneous Catalysis and Sustainable Chemistry	Electives II	3rd	3 ECTS
Laser and Laser Systems	Electives II	3rd	3 ECTS
Non-Disruptive Testing	Electives II	3rd	3 ECTS
Innovation and Entrepreneurship	Complementary Skills II	3rd	2.5 ECTS
Innovation Management	Complementary Skills II	3rd	2.5 ECTS
Master Thesis		4th	30 ECTS

Students choose two electives and two complementary skills per semester.
One elective may be selected from a curated list of the MSc Biomedical Engineering curriculum.

Creative Engineering Lab

At the heart of the program is the unique Creative Engineering Lab: A state-of-the-art learning and teaching laboratory equipped with the latest technology and machines.

Collaborating in interdisciplinary groups and accompagned by an industry partner, students approach the challenge to apply theoretical concepts and develop a product, managing the project from the beginning to the final stage.

Guided by professional experts, responsible laboratory scientists, technicians and lecturers, students have the opportunity to bring their own engineering ideas to live.

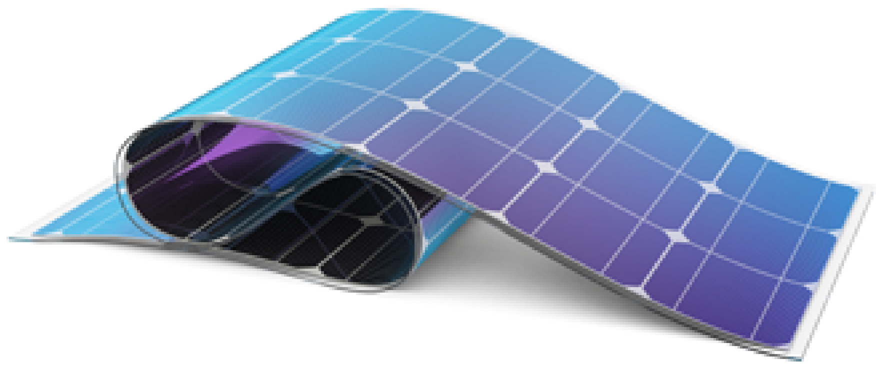

Collaborative Robotics


Electronics Laboratory


Manufacturing Laboratory


Optical Laboratory (BFH)

CE Lab Projects
Ultraprecision Engineering



Development of a compact rotatable and heatable up to 900°C substrate holder for homogeneous thin film deposition by PVD and ALD

Swisscluster SC1 equipment is planned to be installed in the Creative Engineering Lab in summer 2023. This coater is an innovative cluster equipment that combines Atomic Layer Deposition (ALD)/Chemical Vapor Deposition (CVD) with Physical Vapor Deposition (PVD) in a compact, modular, and fully automated system.

In the SC-1, the ALD/CVD and PVD are arranged in compact vacuum chambers divided vertically by a gate valve that is closed when performing ALD or CVD and opens to run a PVD process, without ever breaking vacuum or having to move the substrate during deposition.

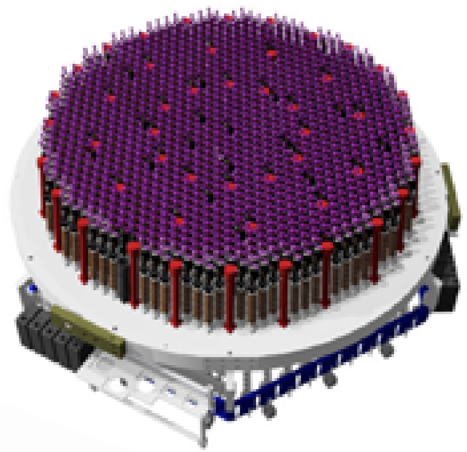
The SC-1 is a perfect tool for the product development of new types of thin films. The possibility to add plasma sources, design new accessories for new processes, and in-situ diagnostics is facilitated by the customized flanges and viewports and avoids the limitations of a rigid system.

In this project, students work in collaboration with Swiss Cluster engineers and design a new substrate holder that will allow the deposition of thin layers at high temperatures on rotating parts along the vertical z-axis.

Swiss Cluster

COAT-X

Micro- and Nanopositioning System for 3D Scanner, Laser Cutter and Microscopy



Linear stages are used in many applications in industry and research including e.g. for 3 D scanners, laser cutters, microscopes to generate a linear motion without lateral deviation and tilt and without backlash (Fig. 1).

The most frequent ones use a leadscrew or a ball screw transmission with a DC motor or stepper motor. Theses systems allow a displacement of 10-1m – 10-6m whereas Piezo driven stages allow displacements down to nanometers (10 5m - 10-10m).

The proposed project consists in combining these two technologies in a closed loop system allowing accurate and precise displacements of 10-1m – 10-9m covering 8 order of magnitude without backlash.

Using an intelligent closed loop control system and linear encoders with nanometer resolution, the piezo-actuator should be used to correct the errors of the ball screw/lead screw & motor system.

Projects steps include
- Mechanics, Simulation and Metrology & Characterisation
- Electronics and Control Systems
- Production Processes
- Materials and Cost Estimation
- Quality and Reliability

mps MICROSYSTEMS

CE Lab Projects
Optical Engineering

Innovative process to manufacture small optical components such as micro-lenses

The goal of this project is to explore and evaluate new approaches to manufacture in volume small but high-quality optical components at low price.

Standard optical components can be miniaturized to a micro-optical scale with the help of miniature lenses, prisms, rods etc. which are compatible with optical fibers and small devices such as a watch or a smartphone.

Another feature of a micro-optics the ability to realize complex optical functions into a compact form.
Optics made from plastic in principle uses the identical algorithms as optic design for glass. On the other hand, designing optics which made from plastic like PMMA requires a profound understanding of the material properties and the manufacturing processes.

Compression molding is one of the techniques to use for the manufacture of micro-optical components or structures. This manufacturing technique is ideal for high volume production with low unit costs. Compared to other production process, optics can be made with different technologies such as additive manufacturing or laser processing.

3D printing of micro-optics is a possible way to realize them and help to lower investments too. Moreover, it is ideal for low volume production. Laser processing of material uses a laser to modify one or more.

The small physical dimensions have various implications concerning fabrication techniques, usable optical materials, relevant physical effects, and performance limitations.

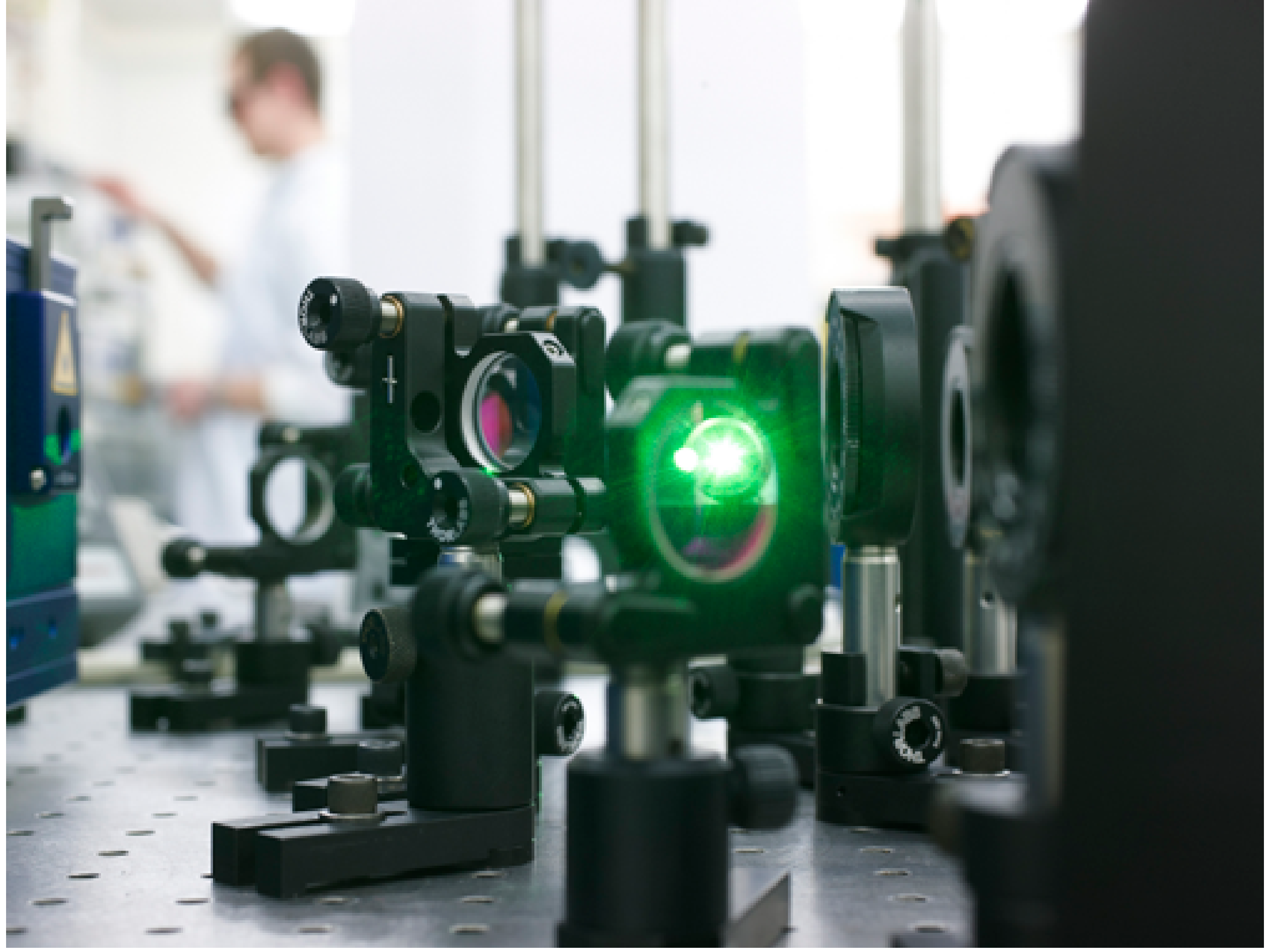
Surface roughness measurement with speckle interferometry

The goal is to explore new arrangements to realize a prototype of a speckle interferometer to measure surface roughness of different materials.

In definition the surface roughness is the measure of the finely spaced micro-irregularities on the surface texture which is composed of three components, namely roughness, waviness, and form. The surface roughness measurement is the measurement of the small-scale variations in the height of a physical surface. This contrasts with larger scale variations such as form and waviness which are typically part of the geometry of the surface. The surface roughness is an important factor in determining the satisfactory performance of a components in different areas such as surface coatings. In surface roughness measurement refers here to two main groups: contact and non-contact or nondestructive measurement.

The image of any object with a rough surface that is illuminated by a laser appears covered with a random granular pattern known as laser speckle or modal noise. Speckle interferometry is a non-destructive measurement technique where the speckled image of an object is made to interfere with a reference field. Any displacement of the surface then results in changes in the intensity distribution in the speckle pattern.

Speckle interferometry permit measurements on objects with rough surfaces. Moreover, the surface roughness of an object can be determined via this method. Changes in the roughness of the surface can be studied by superimposing the object and the reference pattern. If the roughness of the surface has changed, different fringes are obtained.



Qualification Profile
Precision Engineering

Precision Engineering is one of the key technologies for successful innovation and, thus, an entry point to future markets. Graduates of the Master of Science: Precision Engineering will be excellently prepared for the challenges in this multidisciplinary field that connects physics, chemistry, material sciences, microengineering, mechanical engineering, electrical engineering, material engineering, photonics, and information engineering.

In two specializations, students will gain a comprehensive overview of the relevant fields of Ultraprecision Engineering and Optical Engineering respectively in terms of scientific research competence and occupational qualification and application. Graduates will perform engineering tasks in an interdisciplinary context and bridge different engineering areas and professional fields.

The future challenges for industries and in research ask for a new educational approach. The master's program offers an excellent and innovative education that combines professional and highly demanded transversal skills and competencies to prepare graduates for diverse tasks.

The heart and soul of the master's program is the unique Creative Engineering Lab: A state-of-the-art learning and teaching laboratory. Here, students learn and develop their skills with the help of professionals. Students implement technical ideas and concepts into products and services in interdisciplinary groups and understand teamwork and communication in a multidisciplinary environment.

Thanks to a close connection to leading national and international institutions in industry and research, our graduates will acquire access to a valuable network to further develop their understanding and skills and use them for the benefit of society.

The structure includes a doctoral degree program at the School of Biomedical and Precision Engineering at the University of Bern to increase in-depth knowledge.

Professional and methodical competencies

- Understand the fundamental principles of simulation, modularization, optical systems, digital technologies, circular industry technologies, advanced materials, and targeted surface modifications
- Apply the aforementioned technologies in product developments
- Take into account norms, standards, and safety measures in their activities
- Plan and design precise, reliable, safe, and sustainable products
- Use their knowledge to design competitive products that meet global market requirements
- Apply the principles of accuracy and repeatability in product development and implement them in production processes
- Design a complete development cycle including modeling, characterization, engineering, and upscaling, also in an industrial environment
- Combine new and emerging technologies such as additive and subtractive manufacturing, micro-and nanofabrication with the corresponding optical sensor technology, artificial intelligence, and human-robot collaborations and integrate them into production planning
- Solve problems based on both application-based and fundamental methodology
- Transfer specialist knowledge and methodical solution-finding skills to new or highly complex tasks and requirements
- Independently understand new developments as well as concepts and methods from other disciplines and consider them when solving problems
- Realize new and sustainable product characteristics by combing creative methods with advanced technologies
- Plan, structure, and lead comprehensive and complex projects and apply the appropriate project management tools
- Systematically design, conduct, and analyze scientific and/or industrial experiments and communicate the results
- Identify research questions, formulate hypotheses, and work critically with scientific literature
- Conduct patent searches independently or under guidance

Ultraprecision Engineering

- Strengthen and create new types of value chains based on digital industry platforms
- Apply methods to increase productivity through digital transformation with the aim to realizing shorter innovation cycles and lower production costs
- Integrate zero-waste manufacturing, de- and remanufacturing, including smart recycling, reuse of raw material, repairing and refurbishing products into modern manufacturing processes and environments

Optical Engineering

- Understand the common principles of optical sensor technology and measurement technology
- Identify and use suitable optical components for product developments
- Develop unavailable components independently
- Simulate optical systems using relevant software
- Plan complex optical sensor systems considering modern manufacturing processes
- Understand the special requirements for optical systems in extreme environments and special areas of application and implement them in this respect
- Collaborate with related disciplines to realize real-time data acquisition (e.g., image processing) and data analysis

Social and self competencies

- Apply high standards of professional expertise, integrity, autonomy, and self-management in their work
- Cooperate respectfully and solution-oriented in interdisciplinary and transdisciplinary teams
- Generate target group-oriented technical documentation
- Recognize communication needs and requirements of various stakeholders, and consider them for a targeted oral and written communication
- Communicate ideas and results effectively and efficiently in English
- Actively participate in and/or lead scientific discussions
- Critically question results, including own results, and constructively defend them against criticism
- Reflect own actions and question them concerning social expectations, ethical standards and requirements
- Take responsibility for socio-economic, economic, and social aspects of their work, which arise from new developmental and manufacturing processes and products

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SCHAFFT
WERT.

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