Photonics and Laser Engineering

Fields of education: Engineering and Information Technologies

1. Professional qualification

Professional career outline

Photonics is a key enabling technology that interdisciplinarily potentiates application fields. The typical field of work ranges from medical technologies over biotechnology, additive and subtractive manufacturing, communication, sensing, metrology, light harvesting or light generation to name just a few. At the basis of all these tasks is the generation, control, detection and interaction of light.

The main competencies of the graduates of the profile Photonics know and understand the most commonly used photonic components, light-based processes and measurement methods. They use and combine them for dedicated applications, know how to design photonic systems and how they are interfaced to electrical and mechanical systems. Photonic engineers conduct research and do product developments on new photonics technologies; they know how to evaluate the feasibility and market significance of new photonics-based systems.

Further, graduates with a master's degree in photonics are interdisciplinary allrounders. They are predestined for senior positions with management responsibilities in the area of R&D, smart manufacturing, industrial process and quality control as well as automation and digital factories (Industry 4.0).

Professional skills

Graduates of the "Photonics" MSE Master profile have a fundamental understanding of physical principles and processes involved in “Photonics” on a strong scientific background. They have a profound knowledge of photonics systems and are able to combine their previously acquired knowledge (in general in the BSc studies) with the acquired specific photonics knowledge and skills to be-come highly interdisciplinarily thinking and acting professionals in their photonics topics.

Their skills will be in the application of light and lasers in manufacturing (including laser processing of materials), light assisted micro technology, fibre optics, optoelectronics, metrology, vision, advanced imaging, lighting, etc. Further professional skills include the design and development of optical sensing systems for automation and production as well the ability to numerically simulate multidisciplinary systems that include photonics elements. An important professional skill especially sought after by Swiss companies is the ability to interface light to and from mechanical as well as micromechanical optical systems (optomechanics) and electro-optical systems.

In addition to their professional expertise, methodological competences are important: Photonic engineers are able to solve complex problems with adequate methods. They can quickly get an overview of the current state of technology, assess existing scientific approaches and select and apply them according to their own situation. Photonics engineers can evaluate the feasibility and market utility of novel photonics systems.

Their curriculum predestines photonic engineers to lead multidisciplinary project teams. They can communicate, collaborate and interact in an interdisciplinary way with other profiles like Mechanical Engineering, Electrical Engineering, Medical and Biotec-Engineering, Computer Sciences or Data Sciences.

Entry skills

Specific skills are required to enrol in this profile. Students holding one of the following Bachelor degrees generally fulfil these entry requirements.

- BSc in Electrical Engineering (Elektrotechnik)
- BSc in Mechanical Engineering (Maschinentechnik und Maschinenbau)
- BSc in in Microtechnology (Mikrotechnik)
- BSc in Materials and Process Engineering (Material- und Verfahrenstechnik)
- BSc in Systems Engineering (Systemtechnik)
- BSc in Photonics
- BSc in Medical Engineering
- BSc in Data Science

The assessment of the entry skills is part of the enrolment process of the respective school. Students who do not hold one of the above mentioned Bachelor degrees will be individually assessed for their suitability by the respective University of Applied Sciences.

Differentiation to bachelor level

The photonic topics touched in the framework of Bachelor education are mostly focused on fundamentals in optics and electronics. This gives a good basis for a master education in photonics with a very broad range of quite specialised topics.

Master education focuses on the distinct profile topics of the different UAS and profits from the cross sectional basic knowledge from Bachelor education. It further introduces and fosters a scientific approach that allows the graduates to develop a broader vision of their field and develop new solutions.

In this way, MSE graduates have all the prerequisites to lead projects in an industrial environment and work in projects on current research topics.

2. Profile contents

The profile covers the following content:

Photonics is having a high impact on machining and manufacturing. Thus high power and ultrashort pulse lasers have gained an essential role in materials processing. In combination with modern fibre systems and optical diagnostic they have dramatically changed the way manufacturing systems are conceived, which gives high importance to the treatment of the fundamentals and applications of laser-material interaction, optics, imaging and beam delivery related to industrial manufacturing processes like laser welding, cutting, drilling, marking, sintering and 3D additive/ subtractive processes. In these application sectors the analysis of the physics of laser application processes and the handling of their complete process loop must be an issue.

Further, graduates of the profile have a profound knowledge in optical measurements and hence they need to know the fundamentals of light detection, master the most commonly used optical measuring methods, understand their fundamental limitations and are able to use them for various applications such as biomedical analysis, metrology, quality control, and automated production lines. This involves profound knowledge in the fields of imaging systems (e.g. microscopy, vision-based system for quality inspection or biomedical imaging), spectroscopy (e.g. for colorimetry or chemical compound analyses), and interferometry (e.g. for dimensional metrology or optical coherence tomography). In addition, they are familiar with modern optical sensors and are able to select and integrate them, for instance in digital factories.

Also generating, controlling and converting light, which is covered in optoelectronics and electro-optics is of paramount importance to engineer light based systems. Among the light sources that will be understood by the graduates of this profile are lasers, LEDs, OLEDs, displays and thermal sources. The detection of light as well as the knowledge of the optical and electrooptical devices and effects that allow

to shape light spatially, temporally and spectrally are also eminently necessary to achieve light control. Further, optoelectronic devices allow to interface optical to electronic systems.

The design and modelling of photonic systems for free space or guided optical signal processing requires a high level of system simulation including ray tracing, wave optics simulation and thin film design as well as CAD and FEM tools for analysing relevant optical, thermal and mechanical properties. Prototyping, testing, measuring, validating, and optimizing of photonic components, modules or systems completes the interdisciplinary field of work of a photonics system engineer. Besides “classical” photonic systems miniaturised or integrated systems play an increasingly important role today, especially in the field of fibre-optics, integrated optics and optical microsystems for various applications in communication, lighting, manufacturing, metrology, machine vision or medical systems.

The trend towards miniaturisation and the increasing complexity of photonic components re-quire high-precision manufacturing processes to achieve the required performance and to maintain tight tolerances. Furthermore, micro-antenna and plasmonic microstructures open new approaches of optical sensing. In this context, micro technology plays an increasingly important role in the conception and manufacturing of miniaturised optics such as waveguides or micro optics or systems with highly integrated photonic components. Besides lithographic processes in combination with etching technologies, replication processes, thin film technology and pho-tonic packaging play an important role for future photonics engineers.