

- **Course:**

BAE 4153 Future Oriented Production Concepts 2
2 SWS, 3 credits, English, advanced level

The course consists of 2 parts:

Part “Additive Manufacturing” (see description below)

Part “Laser Materials Processing” (see description below)

Course part: Additive Manufacturing

Wednesday: 13:45 – 15:15

Room: Room: T2.4.10

Further details to be announced via e-learning (sign in and check regularly)

- **Instructor:**

Prof. Dr. Carlo Burkhardt

Office: T1.1.05,

Office hours: Wednesday 9:00 pm – 10:00 pm

E-Mail: carlo.burkhardt@hs-pforzheim.de (preferred mode of communication)

- **Overview:**

The course – a combination of lecture, workshops and case studies - provides an advanced knowledge in Additive Manufacturing.

- **Prerequisites:**

Fundamental Knowledge in BAE 4152 Future Oriented Production Concepts 1

- **Learning objectives:**

Since the market launch of AM systems in the 1990s, they have been used for the production of single pieces or small series with a steadily increasing tendency. This is mainly due to the fact that the AM does not require any tools or moulds. Since the 3D file serves as a direct template for the component, the manufacturing process can be accelerated considerably. With increasing complexity of the component, through extended form or function, the use of AM becomes even more important. Complex designs, which can only be manufactured with conventional systems with a great deal of effort, can usually be realized many times more easily with AM systems..

Measured by sales figures and media reports, AM of metals is in a phase of hypes. The volume of AM equipment sold for metals in 2016 was an estimated USD 540 million, with growth of 18% predicted for the coming years. The consumables market was 2016 approximately USD 120 million, with further growth of 15% expected here as well. The metal AM market is distributed as follows: 38% in the USA, approx. 20% in Europe with a focus on Germany, followed by China and Japan with approx. 10% each. This distribution clearly shows that the use of additive manufacturing, contrary to the prevailing trend, is shifting production back to economic areas with higher personnel costs.

In addition to the predicted growth rates, current investments of well-known companies show the importance of metallic 3D printing in future production. The US Start Up Desktop Metal, for example, secured a financing of approx. 300 million USD with a participation of Google Ventures and BMW . With the acquisition of Arcam and Concept Laser, General Electric secured access to AM technology and invested approximately USD 1.4 billion.

Siemens and Airbus announce that they will continue to focus more intensively on 3D printing in the future. The voestalpine Group is also increasingly concentrating on the research and development of new powder materials and has set up its own research center in Düsseldorf for this purpose.

In this context, the lecture intends to provide a comprehensive guidance to understand existing additive manufacturing methods to identify possible applications, existing boundaries and hindrances as to evaluate where additive manufacturing is a possible, cost effective alternative manufacturing method to existing systems.

- **Course topics:**

- Overview Additive Manufacturing (AM) Methods
- Metal AM
- Comparison of AM methods with respect to tolerances, material properties and cost effectiveness
- AM manufacturing and value chain considerations
- Quality Assurance in AM
- AM Case and design study

Contribution to program goals

	Learning Objective	Contribution
1.1	Students demonstrate key knowledge in Technical Basics.	Transfer theoretical knowledge of AM in real application cases.
1.2	Students demonstrate key knowledge in Mechanical Engineering	Transfer theoretical knowledge of AM into machining and production concepts, case study.
1.3	Students demonstrate key knowledge in Business Administration.	Use advanced concepts like Business Model Canvas etc. in order to evaluate
3.	Students are able to apply analytical and critical thinking skills to complex problems.	Transformation and adaptation of AM concepts in future oriented production environments.
4.	Students are able to develop business ethics-based strategies and are able to apply them to typical business decision-making problems.	International and global effects on the strategy and the organization of value chains are considered from ethical and social responsibility perspectives.
5.1	Students demonstrate their ability to express complex issues in writing.	Working out of tasks and case studies, and of a term paper
5.2	Students demonstrate their oral communication skills in presentations and lectures.	Working out and presentation of tasks and case studies in front of the class
6.	Students show that they are able to work successfully in a team by performing practical tasks.	Working out of tasks and problems and presentation of the solutions in teams

- **Teaching and learning approach**

The teaching and learning approach is based on 3 didactical methods:

The theoretical key knowledge and the basic concepts are thought at the lecture. The students gain the methodology and the guidance to know and to implement the introduced concepts and tools. Questions and comments of the students are welcome during the lecture.

After the lecture the students should reflect and sum up the content of the lecture based on course materials provided.

The theoretical knowledge is enlarged and converted into a practical role by workshops and case studies. An active participation in class is an important part of the teaching and learning approach.

The students can always communicate with the instructor and get support and advice by talking or mailing.

- **Exam Requirements**

There is an optional written exam at the end of the semester.

Basically, the following requirements will be graded each separately, and on that basis an average grade per person will be built by the professor:

Active general participation during lectures, and especially in brainstormings, workshops, and case studies.

Individual roles prepared and actively performed in group(s) during workshops and case studies, as defined by and agreed with the professor.

Individual or group voluntary activities/ presentations, as required by or agreed with the professor – as far as reasonably possible.

Maximum 2 lectures (90 minutes each) missed during the course. More absence must be agreed with the professor and be compensated.

Grading, based on exam results:

'Sehr gut' represents exceptional work, far above average.

'Gut' represents good work, above average.

'Befriedigend' represents average work.

'Ausreichend' represents below average work with considerable shortcomings.

„Mangelhaft“ is just exceptional work in the wrong direction or with unacceptable shortcomings.

- **Course materials:**

- Class handouts will be available in the LMS.

- **My teaching philosophy**

In the classes we consider the important concepts, models, principles and phases of strategic and operational management and apply them on a real world situation. I will assist you to develop a self-contained strategic thinking, based on the acquired basic skills, and to evaluate the opportunities and the threats of different strategies and management methods. When not understanding a learning step, you should pose a question during the lesson. I want to support every student who is committed to take the required knowledge and to pass the exams successfully.

- **Tentative Schedule (changes tba)**

Date	Theme
Lecture 1	Topic Introduction
Lecture 2	AM methods for polymeric materials
Lecture 3	AM methods for metals
Lecture 4	AM manufacturing chain/value chain
Lecture 5	AM quality assurance
Lecture 6	Indirect metal AM
Lecture 7	Case Study
Lecture 8	Exam preparation, Q&A

Course part: Laser Materials Processing

Thursday: 09:45 – 11:15

Room: T2.4.10

Further details to be announced via e-learning (sign in and check regularly)

• Instructor:

Prof. Dr. Roland Wahl

Office: T1.3.24

Office hours: Wednesday 8:00 – 09:30

E-Mail: roland.wahl@hs-pforzheim.de (preferred mode of communication)

• Overview:

The course – a combination of lecture and case studies - provides an advanced knowledge in Laser Materials Processing.

Please be prepared for changes in the form of the lecture due to the COVID-situation. This could be:

- **In the first and the last week of the lecture: Presentation could be held via conferencing-software (e.g. Alfaview).**
- **Other regular lecture hours could be given via video-presentation (links would be found in the E-learning-course).**

Participants should sign in to the E-learning-course of this lecture (no inscription key required) because actual informations will be given at semester-start via E-mail to all participants of this course.

• Prerequisites:

Fundamental Knowledge in MEN1270 Fertigungstechnik.

• Learning objectives:

Objectives:

Students have a deep knowledge of important properties of laser beams for effective laser materials processing, especially focussability and beam quality.

Students have knowledge of the basic principles of laser beam guidance, forming and focussing under production circumstances.

Students have a deep knowledge of the processing techniques for the most important and common laser materials processes.

Students have knowledge of important and advanced concepts of employing laser technology in very efficient and cost saving ways in production, e.g. beam-splitting, scanning, robot-scanner-combinations.

Way to reach objectives:

The lecture intends to provide a comprehensive guidance to understand existing laser materials processing devices, machinery and processes.

By understanding the ways of beam and material interaction possible applications, existing boundaries and hindrances can be identified and clearly understood.

By understanding the setups and properties of laser machineries tendencies of cost situations can be clearly understood.

- **Course topics:**

- Fundamentals: Laser beam sources for materials processing, beam characteristics, beam transport via fibers, focusing.
- Laser materials processes: Welding, brazing, cutting, hardening, cladding, drilling, marking. All laser materials processes are described in their function, attainable results and application examples.
- Machineries for laser materials processing: Laser materials processes often allow high feed rates in manufacturing. To take advantage of this in applications in production often advanced machinery has to be employed. Contemporary advanced machinery is described (e.g. robots with scanners or sensors).

Contribution to program goals

	Learning Objective	Contribution
1.1	Students demonstrate key knowledge in Technical Basics.	For comprehension of theoretical and practical contents of the lecture, knowledge of technical basics is essential. Has to be demonstrated during course.
1.2	Students demonstrate key knowledge in Mechanical Engineering.	For comprehension of application concerned contents of the lecture, knowledge of mechanical engineering is essential. Has to be demonstrated during course.
1.3	Students demonstrate key knowledge in Business Administration.	Knowledge in Business Administration is essential for an understanding of the presented cost improvements through future oriented laser processes and machinery in production.
3.	Students are able to apply analytical and critical thinking skills to complex problems.	Transformation and adaptation of advanced laser materials processes and machineries in future oriented production environments.
5.1	Students demonstrate their ability to express complex issues in writing.	The examination is in written form and in English language. The standard is of advanced level. Thus the students have to demonstrate these abilities.
5.2	Students demonstrate their oral communication skills in presentations and lectures.	The lecture is presented in English. Students questions during lecture have to be formulated in english. That's a moment to demonstrate oral abilities in english.

- **Teaching and learning approach**

The teaching and learning approach is based on 3 didactical methods:

The theoretical key knowledge and realized practical applications in production are taught in the lecture. The students gain the methodology and the guidance to know and to implement the introduced contents. Questions and comments of the students are welcome during the lecture.

After the lecture the students should reflect and sum up the content of the lecture based on course materials provided.

The students can always communicate with the instructor and get support and advice by talking or mailing.

- **Exam Requirements**

There is a written exam at the end of the semester.

Basically, an individual grade per person will be built by the professor on base of the written answers in the exam:

Grading, based on exam results:

'Sehr gut' represents exceptional work, far above average.

'Gut' represents good work, above average.

'Befriedigend' represents average work.

'Ausreichend' represents below average work with considerable shortcomings.

„Mangelhaft“ is just exceptional work in the wrong direction or with unacceptable shortcomings.

- **Course materials:**

Class handouts will be available in the LMS.

- **My teaching philosophy**

To give an introduction into a new field of High-Tech which was not mentioned before during the candidates study, like here the field of laser materials processing, the presented lesson should always come along with lessons in lecture style. Following this philosophy of mine, my contents of this course are subsequently presented in lectures. Nevertheless the successful participation at this lecture should enable the students to use the acquired knowledge in later practical use cases in production as well as in development. Therefore all lecture contents are presented oriented to typical use cases in the students later business lives.

- **Tentative Schedule (changes tba)**

Date	Theme
Lecture 1	Topic Introduction. Danger potentials of laser beams.
Lecture 2	Beam quality and focusing of laser beams
Lecture 3	Elements for guidance and focusing of laser beams. Absorption at metals and plastics.
Lecture 4	Laser machinery types for future oriented production concepts
Lecture 5	Laser welding (1)
Lecture 6	Laser Welding (2), Laser cutting
Lecture 7	Laser drilling, marking, deposition welding, hardening