Module title		**SM Code**
Intelligent Materials Systems and Metamaterials		**IWM**
Module lecturer	**Faculty**	
Prof. Dr. Mikhail Chamonine	Electrical Engineering and Information Technology	
Module language	**Number of SWS / WSH**	**ETCS credits**
English / German	4 SWS / WSH	5
Teaching format		
Seminar-based teaching with approx. 15% practical component, student presentations, simulation on computers		

Semester according to the study plan	
1st, 2nd semester (Master)	
Attendance/classroom hours	**Additional independent study**
60 hours	Preparation and follow-up work: 60 hours Exam preparation: 30 hours
Type of examination / Requirements for the award of the credit points	
Written exam: 90 minutes	

Teaching content

Introduction

- Definition of smart materials
- Overview of different classes of smart materials

This course covers several topics from the following catalog:

Piezoelectric materials

- Piezoelectric effect

- Piezoelectric ceramics
- Piezoelectric polymers
- Constitutive modeling
- Applications
- Vibration energy conversion (energy harvesting)

Piezo-resistive materials as smart sensors

- Piezo-resistive effect
- Constitutive modeling
- Applications

Electrostrictive materials

- Electrostrictive effect
- Constitutive equations
- Applications

Giant magnetoresistance effect (GMR)

- Physical effect
- Spintronics
- Applications

Magnetostrictive materials

- Physical effects
- Constitutive equations
- Applications

Shape memory materials

- Shape memory alloys
- Magnetic shape memory alloys

- Electrically conductive polymers as smart materials
- Applications

Magnetic gels (ferrogels)

- Magnetoviscous properties
- Constitutive equations
- Applications

Magnetorheological fluids and elastomers

- Magnetorheological effect
- Physical models
- Applications

Electrorheological fluids

- Electrorheological effect
- Physical models
- Applications

Dielectric elastomers

- Constitutive equations
- Applications

Metamaterials

- Electromagnetic and optical metamaterials
- Elastic metamaterials
- Acoustic metamaterials
- Applications

Smart materials for controlled drug release

- Physical principles
- Applications

Liquid crystal elastomers

- Introduction
- Modeling and constitutive equations
- Applications

Self-healing materials

Janus particles as smart materials

- History and manufacturing methods
- Self-assembly structures
- Behavior in external fields

Learning objective: Professional competence

After successfully completing this module, students will be able to

- know the most important types of smart materials and their areas of application (1)
- explain and mathematically describe physical and chemical phenomena in smart materials using constitutive equations (2)
- draw qualitative conclusions using a small number of physical concepts and laws (2)
- read and understand current technical literature on the topic of "smart material structures and metamaterials" (2)
- understand the concept of “smart materials and smart structures” (3)
- understand the differences between various physical models for a smart material (3)
- design concepts for applications of smart materials (3)
- understand the concept of “metamaterials” (3) and be able to describe it mathematically
- design concepts for applications of metamaterials (3)

Literature

Recommended reading

- Shahinpoor, M. (2020). *Fundamentals of Smart Materials*. Royal Society of Chemistry

The numbers in brackets indicate the levels to be achieved: (1)-know | (2)-can | (3)-understand and apply