COURSE DESCRIPTION CARD - SYLLABUS

Course name
THIN-FILM TECHNOLOGY [S5IMAT>TWCW]

Course

Proposed by Discipline
–

Year/Semester
2/3

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

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Prerequisites

Knowledge: basic knowledge of the core course of physics, chemistry and materials engineering. Skills: knowledge and ability to analyze experimental data. Social competencies: understanding the need to extend the level of competence; responsibility for own work.

Course objective

The purpose of the lecture is: • the understanding of plasma surface interactions during dynamic thin film growth processes on the atomic level, • the identification of mechanisms during the thin film growth itself, • finding correlations between coating design, plasma conditions, film growth, microstructure, properties and coating behaviour which introduce into applications, • gaining knowledge on various reactive and non-reactive physical vapour deposition techniques as well as plasma assisted chemical vapour deposition methods for the development of protective and functional coatings, including materials for lithium ion batteries.

Course-related learning outcomes

Knowledge:
1) recent achievements in the plasma and thin film technology and characterization of materials down to the level of single molecules and atoms, eg. using electron microscopy (SEM, TEM, AFM). [P8S_WG/SzD_W01],

2) focus on computer simulations of thin film growth, which can be used to model and visualize many processes. Structure zone models will be examined and explained in more detail. [P8S_WG/SzD_W02], [P8S_WG/SzD_W03].

Skills:
1) precisely formulate research problems and propose ways to solve them, including choosing right measurement methods to obtain useful information about studied materials, [P8S_UW/SzD_U01],
2) analyze experimental data to obtain information about specific (mechanical, physical, chemical, etc.) properties of the studied materials from macroscale to the nanoscale, [P8S_UW/SzD_U02], [P8S_UK/SzD_U04].

Social competences:
1) critically acquire knowledge from various sources, including online resources, [P8S_KK/SzD_K01], [P8S_KK/SzD_K03],
2) be able to assess the relationship between his/her own research and the world achievements in a given scientific discipline. [P8S_KK/SzD_K01], [P8S_KK/SzD_K02].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Activity, evaluation of students' presentations on subjects related to the lecture, academic discussion, test - quiz - assessment criteria:
sufficient – 50.1%-70.0%, good – 70.1%-90.0%, very good – > 90.1%

Programme content

This course provides a compact introduction to plasma and thin film technology. The necessary fundamentals are presented in a clear manner, and the latest developments are also taken into account. Plasma, especially low-pressure plasma, is a central element in physical vapor deposition (PVD) processes. After presenting the basic aspects of plasma physics, the course covers the targeted manipulation of plasma using electric and magnetic fields and provides an in-depth look at magnetron sputtering and arc evaporation. Plasma diagnostics is a very powerful tool for process control and upscaling and is essential for understanding plasma-wall interactions, such as those involved in sputtering processes. Another focus is on computer simulations of sputtering, surface modification due to ion bombardment and thin film growth, which can be used to model and visualize many processes. Finally, structure zone models are examined and explained in more detail.

Course topics

December 12, 2025 (Friday)
· Introduction to plasma physics
· Interaction of electric and magnetic fields with plasmas
· Magnetron sputtering
· Arc evaporation

December 19, 2025 (Friday)
· Plasma diagnostics
· Sputter theory
· Computer simulations of thin film growth
· Structure zone models

Teaching methods

Lecture: multimedia presentation including illustrations and examples, scientific discussion.

Bibliography

Basic
1. Original lecture materials made available for PhD students by the lecturer.
2. Hartmut Frey, Hamid R. Khan, Handbook of Thin-Film Technology, Springer - Publishing Company Berlin, Heidelberg, 2015, 1st edition, ISBN 978-3-662-50008-8, ISBN 978-3-642-05430-3 (eBook), DOI

10.1007/978-3-642-05430-3
3. Peter A. Dearnley, Introduction to Surface Engineering, Cambridge University Press, New York, 2017, ISBN, 978-0-40168-5
4. R. Behrisch (Editor): Topics in Physics, Volume 52: Sputtering by particle bombardment I and II, Springer - Publishing Company Berlin, Heidelberg, 1983, 1st edition

Additional
1. S. Ulrich, J. Schwan, W. Donner, H. Ehrhardt; Knock-on subplantation-induced formation of nanocrystalline c-BN with r.f. magnetron sputtering and rf argon ion plating; Diamond and Related Materials 5 (1996) 548-551
2. P. Hofmann, R. Gryga, M. Müller, M. Stüber, S. Ulrich, Multiscale simulation of hollow cathode assisted internal plasma treatment process; Multiscale simulation of hollow cathode assisted internal plasma treatment process; Surface & Coatings Technology 442 (2022) 128422-1 – 128422-13; https://doi.org/10.1016/j.surfcoat.2022.128422
3. S. Bauer, B. Nergis, X. Jin , R. Schneider, D. Wang, C. Kübel, P. Machovec, L. Horak, V. Holy, K. Seemann, T. Baumbach, S. Ulrich; Dependence of the Structural and Magnetic Properties on the Growth Sequence in Heterostructures Designed by YbFeO3 and BaFe12O19; Nanomaterials 14 (2024) 711-1 – 711-24; https://doi.org/10.3390/nano14080711
4. André Anders, A structure zone diagram including plasma-based deposition and ion etching, Thin Solid Films, Volume 518, Issue 15, 31 May 2010, Pages 4087-4090

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	2,00