POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name

2D MATERIALS ENGINEERING: FROM SYNTHESIS TO ELECTRONIC DEVICES [S5IMAT>IM2D]

Course

Proposed by Discipline

–

Year/Semester

3/5

Level of study

Doctoral School

Course offered in

English

Form of study

full-time

Requirements

elective

Number of hours

Lecture

4

Laboratory classes

0

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

1,00

Coordinators

dr hab. inż. Wojciech Koczorowski prof. PP
wojciech.koczorowski@put.poznan.pl

Lecturers

dr hab. inż. Wojciech Koczorowski prof. PP
wojciech.koczorowski@put.poznan.pl

Prerequisites

Knowledge: Advanced knowledge of physics and chemistry; basic understanding of the electronic properties of materials. Skills: Strong analytical skills, ability to read and comprehend scientific literature, and a commitment to self-directed learning. Social competencies: Recognition of the importance of continuous professional learning through literature, alongside effective teamwork skills.

Course objective

The course lectures explore key topics in 2D materials, focusing on their processing and real-world applications. Specifically, the syllabus covers selected growth methods for layered materials, their fundamental properties, and characterisation techniques. Additionally, it addresses fabrication workflows for basic electronic devices, highlighting lithography, plasma processing, and magnetron deposition techniques alongside practical device examples.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:

1) scientific achievements covering selected specific issues of 2D materials, their processing, and applications that are relevant to the scientific disciplines studied at the doctoral school, to the extent that enables the revision of existing paradigms, [P8S_WG/SzD_W01]

2) scientific research methodology in disciplines represented at the doctoral school, [P8S_WG/SzD_W03]
3) principles of promoting scientific activity results, also in an open access mode, [P8S_WG/SzD_W04]
4) basics of knowledge transfer from scientific activity to socioeconomic environment. [P8S_WK/SzD_W07]

Skills
A PhD student who graduated from doctoral school can:
1) explain the fundamentals of nanomaterials and their applications in specific fields of technology [P8S_UW/SzD_U01, P8S_UK/SzD_U05]
2) describe new developments, including 2D-materials and applications in electronic devices [P8S_UK/SzD_U05]
3) use the English language to allow active participation in the international scientific and professional community. [P8S_UK/SzD_U08]

Social competencies
A PhD student who graduated from doctoral school is ready to:
1) critically assess the achievements within materials science, [P8S_KK/SzD_K01]
2) acknowledge the importance of knowledge in solving practical problems, [P8S_KK/SzD_K03]
3) to fulfil the social obligations of researchers. [P8S_KO/SzD_K04], [P8S_KO/SzD_K06]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Individual ratings in discussions and quizzes on general subjects related to the lecture.

Assessment criteria
50.1% - 70.0% - (3.0)
70.1% - 90.0% - (4.0)
90.1% - 100.0% - (5.0)

Programme content

1. Introduction to 2D Materials
2. Growth methods of 2D materials
3. Properties of classes of layered materials and their experimental characterisation.
4. Fabrication methods of planar electronic devices.
5. Selected applications in sensors and electronics.

Course topics

1. Introduction to 2D Materials. Basic physical and structural properties
2. Growth methods of 2D materials. Physical and chemical methods: including exfoliation, MBE growth, transformation of metallic layers, use of a zone furnace, etc.
3. Properties of classes of layered materials and their experimental characterisation. Selected 2D materials: graphene, TMD materials, and experimental results from Raman spectroscopy and microscopy.
4. Fabrication methods of planar electronic devices. Procedure for fabricating planar devices using optical lithography.
5. Selected applications in sensors and electronics. Typical test strutures and applications in the snesor tchnologies.

Teaching methods

Lecture: multimedia presentation including illustrations, examples and discussion.

Bibliography

Basic
[1] Das, S., Robinson, J.A., Dubey, M., Terrones, H., Terrones, M., 2015. Beyond Graphene: Progress in Novel Two-Dimensional Materials and van der Waals Solids. Annual Review of Materials Research 45, 1–27. https://doi.org/10.1146/annurev-matsci-070214-021034
[2] Mbayachi, V.B., Ndayiragije, E., Sammani, T., Taj, S., Mbuta, E.R., khan, A. ullah, 2021. Graphene synthesis, characterization and its applications: A review. Results in Chemistry 3, 100163. https://doi.org/

10.1016/j.rechem.2021.100163
[3] Koczorowski, W., Kuświk, P., Przychodnia, M., Wiesner, K., El-Ahmar, S., Szybowicz, M., Nowicki, M., Strupiński, W., Czajka, R., 2017. CMOS- compatible fabrication method of graphene-based micro devices. Materials Science in Semiconductor Processing 67, 92–97. https://doi.org/10.1016/j.mssp.2017.05.021
[4] Liu, Shenghong, Wang, J., Shao, J., Ouyang, D., Zhang, W., Liu, Shiyuan, Li, Y., Zhai, T., 2022. Nanopatterning Technologies of 2D Materials for Integrated Electronic and Optoelectronic Devices. Advanced Materials 34, 1–22. https://doi.org/10.1002/adma.202200734

Additional
[1] Choi, W., Choudhary, N., Han, G.H., Park, J., Akinwande, D., Lee, Y.H., 2017. Recent development of two-dimensional transition metal dichalcogenides and their applications. Materials Today 20, 116–130. https://doi.org/10.1016/j.mattod.2016.10.002
[2] El-Ahmar, S., Koczorowski, W., Poźniak, A.A.A., Kuświk, P., Przychodnia, M., Dembowiak, J., Strupiński, W., 2019. Planar configuration of extraordinary magnetoresistance for 2D-material-based magnetic field sensors. Sensors and Actuators A: Physical 296, 249–253. https://doi.org/10.1016/j.sna.2019.07.016
[3] El-Ahmar, S., Koczorowski, W., Poźniak, A.A.A., Kuświk, P., Strupiński, W., Czajka, R., 2017. Graphene-based magnetoresistance device utilizing strip pattern geometry. Applied Physics Letters 110, 043503. https://doi.org/10.1063/1.4974938

Breakdown of average student's workload

	Hours	ECTS
Total workload	21	1,00
Classes requiring direct contact with the teacher	4	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	21	1,00