

STUDY GUIDE

*ADVANCED FUNCTIONAL THIN
FILMS:
FROM FABRICATION TO DEVICES
2026-2027 S1*

Organised by

Université Polytechnique
Hauts-de-France

1. IDENTIFYING DATA.		
· Course Name.	Advanced Functional Thin Films: From Fabrication to Devices 2026-2027 S1	
· Coordinating University.	Université Polytechnique Hauts-de-France (UPHF)	
· Partner Universities Involved.	None	
· Course Field(s).	Materials Science, Micro/Nanoelectronics, Functional Materials Engineering	
· Related Study Programme.	Master / Doctorate in Materials Science, Electronics, Nanotechnology	
· ISCED Code.	0533: Physics 0714: Electronics and automation	
· SDG.	SDG 7 (Affordable and Clean Energy) SDG 9 (Industry, Innovation and Infrastructure) SDG 12 (Responsible Consumption and Production)	
· Study Level.	M/D	
· EUNICE Key Competencies	Problem solving	
	Teamworking	
	Communication	
	Self-management	
	Cognitive flexibility	
	Digital competence	
	Technical competence	
	Global intercultural competence	

· Number of ECTS credits allocated.	4 ECTS
· Mode of Delivery.	Online live / Online self-study
· Language of Instruction.	English
· Course Dates.	1 October – 30 January
· Precise Schedule of the Lectures.	3h lecture/week Duration: 12 weeks Further details will be confirmed before the course begins
· Key Words.	Thin films; functional materials; ferroelectricity; piezoelectricity;, device physics
· Catchy Phrase.	From materials to devices: Deposition, characterization and nano/microtechnology

· Prerequisites and co-requisites.	<ul style="list-style-type: none"> • Basic solid-state physics • Fundamentals of materials science • The role in device operation such as capacitors, sensors and actuators
· Number of EUNICE students that can attend the Course.	30 students
Number of EUNICE students that can attend the course per institution	Minimum 3 per partner university
· Course inscription procedure(s).	EUNICE website

2. CONTACT DETAILS.

· Department.	Electronics
· Name of Lecturer.	Ngoc Kim Thanh BUI
· E-mail.	ngockimthanh.bui@uphf.fr
· Other Lecturers.	None

3. COURSE CONTENT.

This course provides a comprehensive theoretical framework encompassing the entire scientific spectrum from functional materials to device integration. It introduces the fundamental principles of thin film deposition, including physical and chemical methods, and discusses how process parameters affect microstructure and functional properties. It

particularly emphasizes functional oxide thin films, such as ferroelectric and piezoelectric materials, relevant to sensing and actuator applications.

The course also covers advanced characterization techniques used to study structural, electrical, and electromechanical properties at the micro and nanoscale levels. Finally, the course addresses the theoretical foundations of micro and nanofabrication processes, and how functional thin films are integrated into devices such as capacitors, sensors, and actuators.

4. LEARNING OUTCOMES.

- Explain the key physical mechanisms governing the thin film deposition process.
- Analyze the relationship between deposition parameters, microstructure, and functional properties.
- Understand and interpret techniques for characterizing thin films (structural, electrical, and electromechanical).
- Describe the fundamental principles of micro- and nano-fabrication processes
- Analyze the operation of devices based on functional thin films (capacitors, sensors, actuators)
- Establish links between material properties and device performance

5. OBJECTIVES.

- Provide a coherent theoretical framework linking materials, processing and devices
- Introducing key deposition and characterization techniques used in advanced materials research
- Develop a multi-scale understanding from thin films to functional devices
- Prepare students for research in materials science, microelectronics and nanotechnology

6. COURSE ORGANISATION.

UNITS

1.	<p>Functional Materials for Thin Films</p> <ul style="list-style-type: none"> • Functional oxides (ferroelectric, piezoelectric, dielectric) • Structure/property relationships • Size and interface effects
2.	<p>Thin Film Deposition Techniques</p> <ul style="list-style-type: none"> • Physical methods: sputtering, pulsed laser deposition • Chemical methods: CVD, sol-gel • Growth mechanisms and thermodynamics • Influence of deposition parameters

3.	<p>Characterization of Thin Films</p> <ul style="list-style-type: none"> • Structural characterization (XRD, SEM, AFM) • Electrical characterization (dielectric, ferroelectric measurements) • Electromechanical characterization (piezoelectric response) • Nanoscale probing techniques
4.	<p>Micro/Nano fabrication</p> <ul style="list-style-type: none"> • Photolithography principles • Etching processes (wet and dry) • Metallization and patterning • Process integration concepts
5.	<p>Devices Based on Functional Thin Films</p> <ul style="list-style-type: none"> • Capacitors and dielectric devices • Piezoelectric sensors and actuators • Scaling and performance limitations • Material–device coupling
LEARNING RESOURCES AND TOOLS.	
<ul style="list-style-type: none"> ➤ Lecture notes and slides ➤ Scientific publications (recent journal articles) ➤ Case studies from current research projects 	
PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.	
<ul style="list-style-type: none"> ➤ Lectures ➤ Guided problem-solving sessions ➤ Analysis of scientific articles ➤ Discussions 	

7. ASSESSMENT METHODS, CRITERIA AND PERIOD.

- Written exam (theoretical analysis and problem solving): 50%
- Scientific article review: 30%
- Oral presentation: 20%

Assessment takes place at the end of the semester (Graded)

OBSERVATIONS.

This course reflects current research challenges in the field of functional materials and micro/nano engineering and is closely aligned with ongoing research on thin-film materials and smart devices.

8. BIBLIOGRAPHY AND TEACHING MATERIALS.

Kanno, I., Kotera, H., & Wasa, K. (2012). *Handbook of sputter deposition technology : fundamentals and applications for functional thin films, nanomaterials, and MEMS* (2nd ed.). Elsevier.

Seshan, K. (2012). *Handbook of thin film deposition : techniques, processes, and technologies* (3rd ed.). William Andrew.

Lines, M. E., and A. M. Glass. (2001), *Principles and Applications of Ferroelectrics and Related Materials*, Oxford Classic Texts in the Physical Sciences.

Selected articles from *Advanced Materials*, *Applied Physics Letters*, *Nature*...