SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**University Babes-Bolyai**
1.2 Faculty	**Physics**
1.3 Department	**Condensed matter physics and advanced technologies**
1.4 Field of study	**Physics**
1.5 Study cycle	**Master**
1.6 Study programme / Qualification	**Physics /**

2. Information regarding the discipline

2.1 Name of the discipline	**Physics of thin films**						
2.2 Course coordinator	**Pop Aurel**						
2.3 Seminar coordinator	**Pop Aurel**						
2.4. Year of study	**1/2**	2.5 Semester	**2/4**	2.6. Type of evaluation	**Intermediary and final**	2.7 Type of discipline	**Speciality**

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					38
Additional documentation (in libraries, on electronic platforms, field documentation)					24
Preparation for seminars/labs, homework, papers, portfolios and essays					38
Tutorship					10
Evaluations					10
Other activities:					20

3.7 Total individual study hours	140
3.8 Total hours per semester	196
3.9 Number of ECTS credits	8

4. Prerequisites (if necessary)

4.1. curriculum	• Solid state physics, Thermodynamics and molecular physics
4.2. competencies	• Experimental methods

5. Conditions (if necessary)

5.1. for the course	Video-projector for courses and seminars and free internet access to the lectures.
5.2. for the seminar /lab activities	Research equipments from the Institute of Physics of UBB computers of Physics Department network**.**

6. Specific competencies acquired

Professional competencies	▪ Extensive understanding of solid state physics. ▪ Physics of thin layers ▪ Methods for thin films deposition and characterisation of physical properties ▪ Acquisition, processing and interpretation of experimental data.
Transversal competencies	▪ Materials of technical interest. ▪ Experimental methods of study in material science: X-ray diffraction, neutron diffraction, magnetic, electrical and thermal studies at low and high temperatures and high magnetic fields, Mössbauer spectroscopy, electron microscopy, XPS etc.

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	This course is designed to provide an introduction to the physics of thin films and methods used in the production and characterization of thin films.
7.2 Specific objective of the discipline	We will examine what thin films are, their important properties, how they are produced, and how we can characterize them.

8. Content

8.1 Course	Teaching methods	Remarks
1. Overview of film growth: techniques and physics.		2 hours
2. **Basics**. Solid State Physics - crystal structure and defects, packing arrangements, close packed planes, thermodynamic vacancy concentration; Thermodynamics - change in free energy, phase diagrams. Kinetics - Fick's Laws, Diffusion coef, Arrhenius	Lecture combined with debates. Will be used the video projector and the blackboard.	2 hours
3. **Film formation**. Nucleation and Growth: homogeneous nucleation, critical ; Trapping, Capillarity model (heterogeneous nucleation); Growth modes, island growth, zone models, columnar growth		2 hours
4. **Film formation**. Deposition parameters and their effects on film growth		2 hours
5. **Film deposition.** Evaporation		2 hours
6. **Film deposition.** Sputtering		2 hours
7. **Film deposition.** Laser ablation		2 hours
8. Film characterization. Imaging techniques		2 hours
9. **Film characterization.** Structural techniques		2 hours
10. **Film characterization.** Optical techniques		2 hours
11. **Film characterization.** Electro/magnetic techniques		2 hours
12. **Thin film properties**. Optical properties		2 hours
13. **Thin film properties.** Electrical and magnetic properties		2 hours
14. **Thin film properties.** Mechanical properties, Other properties		2 hours
Bibliography 1.M. Ohring, The Materials Science of thin films,1992 , Library of Condensed Matter physics Department		

2.M.Konuma, “Film deposition by plasma techniques”, Springer Verlag, Berlin, 1992.-Library of Condensed Matter physics Department

3.Julia M. Phillips, “Substrate selection for HTS thin films”, J.Appl.Phys.79(4),1829-1846(1996).

4.King-Ning Tu, J.W.Mayer, L.O.Feldman, “Electronic thin film science for electrical engineers and materials scientists”, 1992 MacmillanPublishing Company, New-York.

5, Kasturi Chopra,” Thin film phenomena” (Editura:McGraw-Hill Company)

6.A.V.Pop, „Introducere in fizica sistemelor vortex”, 2004, Ed.Efes-Cluj-Napoca, Library of Condensed Matter physics Department

8.2 Seminar	Teaching methods	Remarks
1. Basics of thin films		2 hours
2. Growth of thin films		2 hours
3. Film deposition (MBE)		2 hours
4. SEM and AFM		2 hours
5. Superconducting films		2 hours
6. Magnetic thin films		
8.2. Laboratory Measurements shall be made on laboratory research equipment; subgroups of maximum 4 students.	The guidance of the professor, will interpret and discuss the results (laboratory).	
1.Thin film deposition (DC and RF sputtering)		2 hours
2.XRD for thin films		2 hours
3.AFM and SEM to characterise the film morphology		2 hours
4. Electrical resistivity function of temperature of thin films		2 hours
5. AC susceptibility of superconducting films		2 hours
6.EDX for chemical composition of films		2 hours

Bibliography

vacuum:

- V. Comello "RGAs Provide Real Time Process Control" Semiconductor International p. 71, Sept. 1990.
- P. H. Singer "Today's Changing Vacuum Requirements" Semiconductor International p. 59, Sept. 1990.

deposition:

- B. Heinz "Sputter Target and Thin Film Defects" Vacuum & ThinFilm, October 1999, p. 22.
- G. S. Bales et al., "Growth and Erosion of Thin Solid Films", Science, 249, 264 (1990).
- C. R. M. Grovenor, H. T. G. Hentzell and D. A. Smith, "The Development of Grain Structure During Growth of Metallic Films" Acta Metallurgica 32, 773 (1984).
- H. M. Layton "Ultrasonic Cleaning for Semiconductor Wafer Processing" Microelectronic Manufacturing and Testing Jan. 1983.

characterization:

- D. E. Aspnes "The Accurate Determination of Optical Properties by Ellipsometry" p. 89 in Handbook of Optical Constants of Solids, E. D. Palik, ed.
- R. E. Honig "Surface and Thin Film Analysis of Semiconductor Materials" Thin Solid Films 31, 89 (1976).
- S. Fitzgerald "Analysis of Thin Films and Surfaces", Microscopy and Analysis, July 1995, p. 23.
- L. J. Whitman, J. A. Stroscio, R. A. Dragoset, and R. J. Celotta "Manipulation of Adsorbed Atoms and Creation of New Structures on Room-Temperature Surfaces with a Scanning Tunneling Microscope", Science, 251, 1206 (1991).

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

The master's programme aims at providing students with the appropriate tools for further doctoral studies and to become professional experts in the field of solid state physics and material science. The master curricula will be dynamic in permanent connections with top scientific subjects and the job opportunity on the market. To prepare the future PhD students and researchers for the research activities developed in the research institutes and laboratories of Babeş-Bolyai University or exterior to UBB.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Basics: knowledge and understanding of basic properties of thin films.	**Partial examination**	20%
	Synthesis and experimental methods for thin films. Explanation and interpretation of thin film formation	Exam	50%
10.5 Seminar/lab activities	The quality of the experimental measurements. Lecture and laboratory work to strengthen experimental skills.	Supervising all activities Discussion and correction if it will be neccesary of the report	15%
	Research project	Essay on an imposed theme, with public presentation Oral examination	15%
10.6 Minimum performance standards			
➢ knowledge and understanding of basic properties of thin films for applications and interdisciplinary issues ➢ Ability to develop a specific research master project ➢ Planning and carrying out an experiment to characterise thin film			

Date Signature of course coordinator Signature of seminar coordinator

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Date of approval Signature of the head of department

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