《Thin Film Physics and Technology》Syllabus

Course Number: NANA 2069

Course Name: Thin Film Physics and Technology

Course Category: Elective

Credits/Contact Hours: 3/54

Evaluation Method: Quizzes, short presentation, class activity, midterm exam, final exam

Semester: B

Prerequisites: NANA 1060 Characterization Techniques of Nanomaterials

Follow-Up: NANA 1060

Lecturer: Igor Bello

Syllabus Author: Igor Bello

Syllabus Reviewer: Liu Yang

Text Book:

- I. Bello, Thin Film Physics and Technology, Textbook 3rd edition, Suzhou University Press 2019, pp 313.
- I. Bello, Thin Film Physics and Technology, Lecture Presentation 2019, continuously updated.
- I. Bello, Vacuum and Ultravacuum: Physics and Technology, CRC Taylor Francis, New York 2018, Chapters from 3.12 to 3.24, ISBNI 13-978-1-4987-8204-3.
- I. Bello, 134 Learning Questions with answers.
- Tutorial Calculation Notes in 3 sections.

(1) Specific Goals for the Course

The course specific goals are to (i) acquire knowledge in processing of different thin film structures (elementary materials and compounds in crystalline, polycrystalline, nanocrystalline, and amorphous forms); (ii) develop and engineer thin film materials, and contribute in advancement of thin film technologies that are applicable in industry, research, and science; (iii) to develop students' ingenuity in experiment design and material processing as well as development of novel technologies; (iv) facilitate an interface between the school and industrial and scientific practice; (v) develop ability to design various thin films and tailor their properties by controlling the deposition parameters of a selected deposition technique; (vi) to acquire qualification that will enable students to work in creative working environment.

By the end of the course students will be able to (i) Describe fundamental growth processes and material parameters in thin films and nanomaterial deposition such as growth rate, arrival rate ratio, surface energy, lattice parameters, density, stress, adhesion, stoichiometry, sticking coefficient, etc.; (ii) Explain the effect of variable deposition parameters on the structural evolution; (iii) Design depositions and syntheses of various materials; (iv) Explain mechanism and kinetics in deposition of materials/nanomaterials; (v) Select modern techniques of deposition for particular materials and conduct the deposition; (vi) Apply the obtained knowledge to prepare different materials/nanomaterials at proper

conditions; (vii) Evaluate and select the most suitable processes of material syntheses to obtain desired material properties for functional coatings.

(2) Topics of the Course

- Gas phase, plasma, thin films, formation of thermodynamically stable cluster; nucleation, growth process, requirement for substrates.
- Properties of thin films: microstructure, single crystalline films, polycrystalline films. nanocrystalline, amorphous films, surface morphology, film density. stress in thin films, adhesion, stoichiometry, mechanical, electrical, thermal, chemical, and optical properties of thin films.
- Thermal evaporation; resistance evaporation; electron beam evaporation; molecular beam epitaxy, and laser ablation.
- Electrical discharges and practical configurations at direct current and radio frequency deposition; microwave and electron cyclotron resonance plasma deposition.
- Matching units; floating potential; bias potential; plasma potential; effective bias; self-bias.
- Physical deposition techniques; direct current and radio Frequency sputtering; magnetron sputtering; cathodic arc deposition; filtered cathodic arc deposition; ion beam sputtering; and ion plating.
- Chemical vapor deposition techniques (CVD); thermally activated CVD Plasma enhanced CVD; oxidizing and nitriding; photo-assisted CVD; plasma polymerization; chemical transport in plasma; hydrogen neutralization is semiconductors.
- Other processing technologies; pattern transfer; reactive ion etching; ion milling; and ion beam dry etching.

(3) Assessments for the Course

- Course Score = Class Activity (CA 10%) + Quizzes/Mini Project Presentation (QP 30%) + Midterm Exam (ME 30%) + Final Exam (FE 30%)
- Achievement of Course Goal = (CA Mean Score*CD Weight*0.1 + QP Mean Score*QP weight*0.30 + ME Weight*Mean Score*0.3 + FE Weight*Mean Score*0.3)/(100*CA Weigh*0.1 + 100*QP Weight*0.3 + 100*ME Weight*0.3 + 100*FE Weight*0.3)
- Achievement of Course Goal

Course goals	**Class Activity Weight (10 %)**	**Quizzes/ Presentation Weight (30 %)**	**Midterm Exam Weight (30 %)**	**Final Exam Weight (30 %)**
(i) Apply knowledge in thin film technology and in the fields of materials/nanomaterials, semiconductor devices, engineering and development where thin films form a solid engineering	0.3	0.5	1	1

and scientific base. Solve problems and design technological processes in relevant fields of engineering and development. (Support Graduation Requirements Indicator 1-2)				
(ii) Review literary resources with high proficiency and apply the review to the current engineering and scientific problems in the fields that are strongly supported by thin film technology, particularly materials/nanomaterials engineering and semiconductor devices (Support Graduation Requirements Indicator 2-2)	0.7	0.5	0	0

Assessment Bands:

Course Goal	90-100 (Excellent)	75-89 (Good)	60-74 (Pass)	0-59 (Fail)
(i) Apply knowledge in thin film technology and the fields of materials/nanomaterials, semiconductor devices where thin films form a solid base in engineering and development. Solve problems and design technological processes in relevant fields of engineering and development, (Support Graduation Requirements Indicator 1-2)	Learning outcome is strongly supported by completing all assessment tasks and the ability to demonstrate excellent understanding of engineering or/and scientific principles, the working mechanisms of instruments/devices, or physical phenomena. The student can thoroughly identify and explain how the obtained knowledge and physical principles apply to materials science	Learning outcome is evidenced by completion of all assessment tasks/activities and the ability to describe and explain the engineering or scientific principles well. The student has the ability to evaluate physical principles in detail, apply them to thin film technology and related field and solve relevant physical and	Learning outcome is evidenced by completing the given assessment tasks and the ability to briefly describe and explain some engineering or scientific principles. The student is able to provide simple but fairly accurate evaluations of the physical and engineering principles applied to science and technology and solve most physical and	The attainment level of learning outcome is poor, as evidenced by a failure to complete the assessment tasks. The student has inability to accurately describe assessment tasks The student fails to identify and explain the principles applied to the technology and to solve physical and engineering problems objectively or systematically. The student has insufficient

	and technology, and can solve physical and engineering problems. Learning outcome is strongly supported by the evidence of original thinking.	engineering problems.	engineering problems.	ability to present fundamental principles and phenomena.
ii) Review literary resources with high proficiency and apply the review to the current engineering and scientific problems in the fields that are strongly supported by thin film technology, particularly materials/nanomaterials engineering and semiconductor devices (Support Graduation Requirements Indicator 2-2)	Strongly evidenced the ability to properly use educational media and information resources other than taught materials. The student is able to communicate ideas effectively and persuasively via written and/or oral presentation. The student has the ability to communicate simple ideas in writing and/or oral presentations	Students have ability to use educational media and information resources and the ability to integrate taught concepts, analytical data and applications via good oral and/or written communication.	The student can use educational media and has the ability to communicate simple ideas in writing and/or oral presentations.	The attainment level in using education media and proficiency in analysis of data, writing and presentation is poor and/or the student's work shows evidence of plagiarism.