FISI 4058: UNDERGRADUATE RESEARCH

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UNIVERSITY OF PUERTO RICO, RIO PIEDRAS CAMPUS

Course: FISI 4058: Undergraduate Research
Instructor: Dr. Ratnakar Palai
Credits: 3-credit per semester
Class hours: 3 contact hours
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Research Associate: TBA

Prerequisites: Permission from Professor

Course Description:
Our current research is focused on the following topics:

1. Growth and characterization of multiferroic materials for spintronic applications.
2. Growth and characterization of rare-earth-doped III-Nitride semiconductors for spintronic and spin-polarized photocathode applications.
3. Fabrication and characterization of coin-cell supercapacitors
4. Synthesis and characterization of materials for nuclear radiation detection.

The research will be focused on growth and characterization of various thin films by different techniques such as, molecular beam epitaxy (MBE), pulsed laser deposition (PLD), atomic layer deposition (ALD), sputtering, and spray pyrolysis. The course will also discuss different characterization techniques for the better understanding of film properties and device parameters. The undergraduate research student will work under the supervision a qualified researcher (Professor, PhD student or Postdoc) on an assigned project. The student and advisor meet regularly to discuss the progress of assigned tasks and the course of action to be followed. Through this course, the student gains direct experience with the culture of scientific research while becoming aware of current research trends.

Course Objectives
Through this research experience, the student will learn thin film growth mechanisms and various analytical techniques used to analyzed the materials and related scientific concepts. The student will become familiar with the culture of scientific research.

Content Outline and Time Distribution:

Weeks	No. Hours	Topics
weeks 1-5	15	**Review of literature** • Review of literature and discussion about the importance of project. • Vacuum science and technology- covering physics of vacuum and different pumps. Presentation by PI and student
weeks 6-10	15	**Material synthesis & Characterization:** • Thin film growth mechanisms and principle of different thin film growth techniques molecular beam epitaxy (MBE), pulsed laser deposition (PLD), atomic layer deposition (ALD), and sputtering. • Characterization of thin films using different analytical techniques. Presentation by PI and student
weeks 11-15	15	**Presentation & Research Report Submission** • Discussion of recent development in the project & presentation results. Submission of brief report. Presentation by students

Instructional Strategies:
The instructional method of the seminar is based on the discussion of current review articles and oral presentations.

Minimum resources available: Audiovisual and conference room projectors.

Evaluation Strategies:
Each student has to give three presentations and discussing relevant scientific data, experimental observation supported by scientific argument.
Active participation- 25%
Oral presentation -50%
Research Report (4-5 pages)-25%

Rating system: Approved or not approved

Suggested Textbook:

- M. Ohring, The Materials Science of Thin Films, Academic Press, Inc., (1992).
- K.L. Chopra, Thin Film Phenomena (1969)

Bibliography:

- B. Lewis and J.C. Anderson, Nucleation and Growth of Thin Films, Academic Press, New York, (1978).
- J.A. Venables, Introduction to Surface and Thin Film Processes, Cambridge University Press, (2000).
- J.S. Horwitz and J.A. Sprague, in Film nucleation and Film Growth in
- Pulsed Laser Deposition of Thin Films (D.B. Chrisey and G.K. Hubler, Editors), John Wiley & Sons, Inc., (1994).
- M. A. Herman and H. Sitter, Molecular Beam Epitaxy- Fundamental and current Status (1996)

Recommended Internet resources:

Reviews:

1. http://physics.aps.org/articles/pdf/10.1103/Physics.2.20 (Classifying multiferroics Mechanisms and effects)
2. http://journals.aps.org/rmp/pdf/10.1103/RevModPhys.76.323 (Spintronics: Fundamentals and applications)
3. https://www.sciencedirect.com/science/article/pii/S2352152X24021492 (A review of supercapacitors: Materials, technology, challenges, and renewable energy applications)
4. https://iopscience.iop.org/article/10.1088/1742-6596/1973/1/012015 (A review on Supercapacitors: types and components)
5. https://www.extrica.com/article/24103 (Review of supercapacitor technology and applications)
6. https://www.preprints.org/manuscript/202405.1509 (Overview of Supercapacitors: A Comprehensive Review)
7. https://www.cambridge.org/core/journals/journal-of-materials-research/article/abs/radiation-detector-materials-an-overview/A3A9F7AE62F86BB7B0A147500357635F (Radiation detector materials: An overview)
8. https://www.bnl.gov/video/index.php?v=880 (Photocathodes: A Fundamental Tool for Enabling New Accelerator-based Science)
9. https://pubs.rsc.org/en/content/articlelanding/2023/tc/d2tc03729g (Review of photocathodes for electron beam sources in particle accelerators)

Rights of Students with Disabilities:

UPR complies with all Federal and State Laws and regulations regarding discrimination, including the Americans with Disabilities Act 1990 (ADA) and the Commonwealth of Puerto

Rico Law 51. Students receiving services through Rehabilitation Vocational must contact the professor at the beginning of the semester in order to plan for a reasonable accommodation and any required support equipment according to the recommendations given by the Oficina de Asuntos para Personas con Impedimentos (OAPI) of the Dean of Students. Likewise, students with special need that require some type of accommodation must contact the professor at the beginning of the semester.

Reasonable Accommodation:
The University of Puerto Rico complies with all federal, state and regulations concerning discrimination, including "The American Disabilities Act" (Law ADA) and Law 51 of the Commonwealth of Puerto Rico. Students receiving vocational rehabilitation services should contact the teacher at the beginning of the semester to plan for reasonable accommodation and necessary support equipment in accordance with the recommendations of the Office of Matters for Persons with Disabilities (OAPI) of the Dean of Students. A request for reasonable accommodation does not exempt the student from meeting the academic requirements of the course.

Academic Integrity:
The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR General Student Regulations (Certification Num. 13, 2009-2010, of the Board of Trustees) states that "academic dishonesty includes, but is not limited to: fraudulent actions, obtaining grades or grades academics using false or fraudulent simulations, copying all or part of another person's academic work, plagiarizing all or part of another person's work, totally or partially copying another person's answers to the questions of an exam, making or getting another take in your name any oral or written test or exam, as well as help or facilitation for another person to incur such conduct. "

Harassment:
The University of Puerto Rico prohibits discrimination based on sex and gender in all its forms, including sexual harassment. According to the Institutional Policy against Sexual Harassment at the University of Puerto Rico, Certification No. 130, 2014-2015 of the Governing Board, if a student is being or was affected by behaviors related to sexual harassment, he can go to the Office of the Student Prosecutor's Office, the Office of the Dean of Students or the Compliance Coordinator with Title IX for guidance and / or filing a complaint.