ESE 538: Nanoelectronics, Spring 2025

Instructor	***Email***
Vera Gorfinkel	vera.gorfinkel@stonybrook.edu

3 credits, Letter graded (A, A-, B+, etc.)
This course will meet once a week for 2 hours and 50 minutes.
Syllabus author: Vera Gorfinkel <vera.gorfinkel@stonybrook.edu>

Description

The major goals and objectives are to provide graduate students with knowledge and understanding of physical background and applications of nanoelectronics. The course will cover electrical and optical properties of materials and nanostructures, fabrication of nanostructures, nanoelectronic devices including resonant-tunneling devices, transistors, and single-electron transfer devices, as well as applications of nanotechnologies in molecular biology and medicine.

Prerequisites: Undergraduate students need permission from the instructor to be enrolled in the course.

Course objectives/Student learning outcomes:

The course intends to give students a broad understanding of fundamentals, fabrication technologies and applications of nanoscale structures. Students will also be trained for literature study and critique, oral presentation, problem formulation, solution development, and formal writing. Students who have completed this course will

1. be able to describe existing fabrication technologies and how nanoscale structures can be applied
2. be able to apply Schrodinger equation to electrons in low-dimensional structures
3. be able to formulate problems in nanoelectronics and assess solutions to them

Recommended Reading

- “Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications”, V. Mitin, V. Kochelap, and M. Stroscio, Cambridge University Press, 2008.
- “Emerging Nanoelectronic Devices”, Edited by A. Chen et al., Wiley, 2015
- “Nano comes to life: How nanotechnology is transforming medicine and the future of biology”, S. Contera, Princeton University Press, 2019.

Content

Week 1	Introduction (from classical electronics to nanoelectronics) – *R. Feynman, “There's Plenty of Room at the Bottom”* Fabrication of nanostructures – *Top-Down and Bottom-up Fabrication* – *MBE and MOCVD for fabrication of quantum wells and superlattices* – *Nanolithography*
Week 2	Quantum mechanical concepts – *Wave-particle duality, Uncertainty Principle, Pauli Principle*
Week 3	Quantum mechanical concepts *(continued)* – *Schrödinger wave equation*
Week 4	Electrons in low-dimensional structures – *Electron in quantum well*

	– *Electron in quantum wire* – *Electron in quantum dot*
Week 5	Electrons in low-dimensional structures – *Electron Tunneling* – *Electron in superlattice* **Solving problems, preparation for the Midterm Exam**
Week 6	Statistics of the electrons and holes in semiconductors – *Time and length scales of the electrons in solids* – *Electron transport in nanostructures*
Week 7	Nanoelectronic transistors (MOSFET) – *Historical and Future Trend of MOSFETs* – *MOSFET scaling* – *FIN FET*
Week 8	Spintronics – *Introduction* – *Spin-FET* – *Spin-MOSFET* – *Magnetic logic circuits*
Week 9	Graphene electronics – *Properties of graphene (Band diagram, carrier transport, heat transport)* – *Graphene MOSFET* – *Graphene spintronics*
Week 10	Carbon nanotubes – *Electronic Structure of a CNT* – *Electron Transport* – *Operation of the CNT FET*
Week 11	Nanoelectronics sensors – *Quantum dot-based sensors* – *Nanowire-based sensors* – *CNT-based sensors*
Week 12	Nanotechnology for medicine and biology – *Nano in medicine*
Final Exam	**Term paper group presentations*)**
***)** After the Midterm Exam, student teams will be given topics to prepare their Presentations and Reports	

Grading

Homework	10%
Midterm	45%
Presentation and Report	45%

The University Senate Undergraduate and Graduate Councils have authorized that the following required statements appear in all teaching syllabi (graduate and undergraduate courses) on the Stony Brook Campus:

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.