

CSIR-PGRPE-2011 Programme Brochure

(2011-2013)

Two-year Post-Graduate Research Programme in Engineering (PGRPE) in Advanced Semiconductor Electronics at CSIR-CEERI, Pilani

This programme aims to provide in-depth exposure to the engineering concepts, scientific principles, research methodology and hands-on experience on advanced real-life R&D projects in different specializations of semiconductor electronics. Students completing this two-year programme will be fully research-enabled and industry-ready.

The first semester of the programme focuses on core subjects and associated laboratories related to semiconductor electronics.

The second and third semesters offer elective courses for specialization in the areas of :

- MEMS and Microsensors.
- Nanoelectronics.
- VLSI Design.
- Optoelectronics and Photonics.

The third and fourth semesters give the opportunity to the candidates to effectively utilize the knowledge acquired through the courses towards advanced R&D project work and dissertation in their specialization areas.

In addition, on successful completion of the programme with distinction, the candidates may be considered by CSIR for absorption as Scientists in PB-3 of the Government of India (Scale of Rs. 15600/- to 39100/- with Grade Pay of Rs. 6600/- plus other allowances as applicable).

The medium of instruction and evaluation is English.

Number of Seats in the Programme

The total number of seats available is 8. The allotment of specializations will be done based on the candidate's performance and preference at the end of the first semester.

Admission Process and Eligibility for Admission

Please see the CSIR-PGRPE-2011 website at <http://pgrpe.csio.res.in/> for on-line submission of the admission form and details of eligibility.

Fellowship

Fellowship amount of **Rs. 25,000 per month** will be awarded to selected candidates during the two-year programme. The selected candidates will be designated as "Scientist Trainee" under the CSIR QHS scheme.

Programme Fee Structure

1. One-time Admission Fee (non-refundable) : Rs. 4,000.
2. One-time Security Deposit (refundable) : Rs. 6,000.
3. Semester Fees (non-refundable) : Rs. 24,000.

Students wanting to withdraw from the programme after deposit of fees and security amount will need to apply in writing for refund. If such an application is made on or before July 31, 2011 at CEERI, refund of fees/other charges will be made after deducting the admission fee amount of Rs. 4,000.

No refund of fees/other charges will be made if the student leaves after joining the programme except for the security deposit / caution money amount of Rs. 6,000.

Total amount of Rs. 34,000 needs to be deposited at the time of admission. Subsequently, only the semester fees of Rs. 24,000 needs to be deposited before the start of every semester.

For NEFT bank transfer, please transfer the amount to the saving account number 61033385318 of “Director, CEERI” at SBBJ, Pilani (IFSC code SBBJ0010398) with appropriate narration statement.

In case of Demand Draft, please get it issued in favour of “Director, CEERI” payable at Pilani and post it by speed post or registered letter to “Director, CEERI, Pilani – 333 031” with your name written in pencil on the reverse side of the demand draft.

Important Dates

1. Last date for receipt of on-line application form on CSIR-PGRPE website : May 23, 2011.
2. Programme registration at CSIR-CEERI, Pilani : August 08-09, 2011.
3. Start of first semester at CSIR-CEERI, Pilani : August 09, 2011.

The detailed academic programme calendar will be made available before the start of each semester.

Please visit the CSIR-PGRPE-2011 website at <http://pgrpe.csio.res.in/> for more information. You should also periodically visit CEERI's website link for CSIR-PGRPE-2011 at <http://www.ceeri.res.in/> for updates and news about this programme.

Semester-wise Scheme : Advanced Semiconductor Electronics

Semester-I

Subject Code	Subject	Credits
ASE 501	Physics of Semiconductor Materials and Devices	4
ASE 502	Unit Processes in Semiconductor Technologies	3
ASE 503	CMOS Digital VLSI Design	3
ASE 512	Lab: Unit Processes in Semiconductor Technologies	2
ASE 513	Lab: Physical CMOS-based Design	2
ASE 551	Technical Communications	2
ASE 552	Research Methodology	1

Semester-II

Subject Code	Subject	Credits
ASE 601	Characterization Techniques for Semiconductor Materials, Technologies and Devices	3
ASE 60x	Elective-I	3
ASE 60x	Elective-II	3
ASE 621	Lab: Characterization and Measurement Techniques	2
ASE 62x	Lab/Seminar: Elective-I Related	2
ASE 62x	Lab/Seminar: Elective-II Related	2
ASE 651	Project Management	2

MEMS and Microsensors (Elective-I and Elective-II)

Subject Code	Subject	Credits
ASE 602	MEMS Technology, LTCC and Packaging	3
ASE 603	Physics and Design of MEMS and Microsensors	3
ASE 622	Lab: MEMS Technology, LTCC and Packaging	2
ASE 623	Lab: Design of MEMS and Microsensors	2

Nanoelectronics (Elective-I and Elective-II)

Subject Code	Subject	Credits
ASE 604	Nanoelectronic Devices and Technologies	3
ASE 605	Advanced VLSI Technologies and Devices	3
ASE 624	Lab: Nanoelectronic Technologies	2
ASE 625	Lab: Study and Seminar on Advanced VLSI Technologies	2

VLSI Design (Elective-I and Elective-II)

Subject Code	Subject	Credits
ASE 606	CMOS Analog Design	3
ASE 607	Advanced VLSI System Architectures	3
ASE 626	Lab: CMOS Analog Design	2
ASE 627	Lab: HDL-based Digital Design	2

Optoelectronics and Photonics (Elective-I and Elective-II)

Subject Code	Subject	Credits
ASE 608	Optoelectronic Materials, Devices and Technologies	3
ASE 609	Photonic Materials, Devices and Technologies	3
ASE 628	Lab: Optoelectronic Devices and Technologies	2
ASE 629	Lab: Photonic Devices and Technologies	2

Semester-III

Subject Code	Subject	Credits
ASE 701	Advanced Self-Study on Special Topic	4
ASE 661	Project Work and Seminar	14

Semester-IV

Subject Code	Subject	Credits
ASE 671	Dissertation Seminar and Viva-voce	4
ASE 672	Dissertation Report	14

Brief Course Descriptions : Advanced Semiconductor Electronics

ASE 501 : Physics of Semiconductor Materials and Devices (4-1-0-4) 4 Credits

Faculty Coordinators : Dr. J. Akhtar; Dr. Chandra Shekhar; Dr.S. C. Bose

Semiconductors; Inorganic and organic, single crystalline, polycrystalline, porous, amorphous crystal structures, and material properties; Si, GaAs, GaN, SiC; Energy band diagrams; Dielectric constant, permeability, permittivity, sheet resistance, resistivity, mobility, thermal conductivity and heat dissipation; Piezo-resistive and piezo-electric effects; Defects, dislocations and micro-plasma, phonon dynamics, ion-solid interactions; Electron transport in semiconductors, minority carrier life time, avalanche breakdown phenomena, Hall effect; Theory of p-n junction, Schottky barrier, MOSFETs and MESFETs, IMPATTs and BARRITTs; Hetro-structures, strained semiconductors; Photovoltaics and solar cell; Solid state sensors and transducers; MOS analysis.

ASE 502 : Unit Processes in Semiconductor Technologies (3-0-0-3) 3 Credits

Faculty Coordinator : Dr. G. Eranna

Crystal growth techniques, wafer preparation and shaping, chemical cleaning, thermal oxidation, photo-lithography, chemical etching (wet and dry), chemical vapor deposition techniques, thermal diffusion, ion implantation, metalization, chemical mechanical polishing, rapid thermal processing.

ASE 503 : CMOS Digital VLSI Design (3-0-0-3) 3 Credits

Faculty Coordinators : Dr. A. Karmakar; Dr. S. C. Bose

Introduction to MOSFET from designer's viewpoint; MOS inverter : static and switching characteristics; MOS capacitor; Layers in VLSI design; Design rules and technology interface; Stick diagrams and Layout design; Propagation delay, Fan-out consideration; CMOS Latch-up; Scaling; Combinational MOS logic circuits : pass-transistors/transmission gates, primitive logic gates, complex logic gates; Sequential MOS logic circuits : latches and flip-flops; Dynamic logic circuits; Clocking issues; CMOS subsystem design.

ASE 512 : Unit Process in Semiconductor Technologies Laboratory (0-1-3-2) 2 Credits

Faculty Coordinator : Dr. G. Eranna

Laboratory practices and safety considerations; Wafer preparation and shaping; Chemical cleaning; Thermal oxidation, photo-lithography; Wet chemical etching; Dry etching; Chemical vapor deposition; Thermal diffusion; Ion implantation; Metalization.

ASE 513 : CMOS-based Physical Design Laboratory (0-1-3-2) 2 Credits

Faculty Coordinator : Dr. A. Karmakar

Laboratory practices and safety considerations; SPICE simulation; Schematic editor, Layout editor, DRC, LVS; Transfer and output characteristics NMOS transistor, parameter variations; CMOS inverter design, inverter threshold, noise margin, propagation delay; Layout of CMOS inverter, n-well design rules, LVS, static and transient characteristics, DRC; 2-input NAND/NOR gate; D latch and flip-flop; Post-extract simulation.

ASE 551 : Technical Communications (2-1-0-2) 2 Credits (Same as AES 551 and MDSE 551)

Faculty Coordinator : Sh. Raj Singh

Role and importance of technical communication; Effective written and oral communication; Ethical issues; Technical report writing; Technical/R&D proposals; Research paper writing; Letter writing and official correspondence; Emails; Oral communication in meetings and group discussions; Oral presentations; Use of modern aids.

ASE 552 : Research Methodology (1-1-0-1) 1 Credit (Same as AES 552 and MDSE 552)
Faculty Coordinator : Sh. Raj Singh

Introduction, terminology, and scientific methods; Types of research; Research process and steps; Identifying a research problem; Literature survey, appreciation of existing literature, identification of knowledge gaps; Conception of novel approach to solve the problem; Role of theory, modeling, and simulation; Design of experiments, testing and characterization strategies; Quantitative methods and data analysis; Qualitative analysis; Communicating research results; Ethics in research.

ASE 601: Characterization Techniques for Semiconductor Materials, Technology and Devices
(3-0-0-3) 3 Credits

Faculty Coordinators : Dr. K. J. Rangra; Dr. J. Akhtar; Dr. G. Eranna

Resistivity, Contact resistance, barrier height, carrier and doping concentration, mobility and carrier life time measurement techniques; Test structures for technology characterization; Analysis of surfaces, interfaces, thin films and devices; E-beam based techniques, Scanning Electron Microscopy and allied techniques; Material analysis techniques; Scanning probe Techniques; Ion-beam based techniques; Interferometry based techniques for materials and device characterization; Optical characterization.

ASE 602 : MEMS Technology, LTCC and Packaging (3-0-0-3) 3 Credits

Faculty Coordinators : Dr. V. K. Khanna; Sh. B. D. Pant; Dr. P. K. Khanna

Review of Silicon crystal and unit processes; Processing steps for MEMS device fabrication; photolithography and backside mask alignment; Surface and bulk micro-machining techniques; Deep reactive ion etching; LIGA process; Wafer-level bonding and packaging techniques; LTCC technology, materials, LTCC process steps, bonding and packaging; Testing and characterization of technology; Reliability and residual stress issues.

ASE 603 : Physics and Design of MEMS and Microsensors (3-0-0-3) 3 Credits

Faculty Coordinators : Dr. Ram Gopal; Dr. K. J. Rangra; Dr. Ajay Agarwal

Overview of Microsensors; Mechanical properties of materials and essentials of structural mechanics; Electro-mechanical, magneto-mechanical and piezo-based sensing; Structural elements for MEMS and microsensors (Beams, plates, cantilevers, bridges and diaphragms); Electrostatic sensing and actuation (parallel plate and torsional structures, time domain analysis); Micro-fluidics; Scaling laws and miniaturization; Micro-system design principles; MEMS simulation and design Tools; RF MEMS; Reliability issues in microsensors; Examples and applications of MEMS microsensors.

ASE 604 : Nanoelectronic Devices and Technologies (3-0-0-3) 3 Credits

Faculty Coordinator : Sh. Anil Kumar

Low-dimensional structures (Quantum well, quantum wire, quantum dot, quantum confinement); Confinement energy level, band-gap enhancement, absorption-emission spectra, blue shift, luminescence; Nanoelectronic Devices (Single electron box, Coulomb blockade, single electron transistor, pump, turnstile, trap, memory); Simulation, Modeling of single electron devices and applications; Technology for fabrication of nanostructures and nanoelectronic devices; Next generation lithography techniques; Characterization of nanoscale materials and nanodevices.

ASE 605 : Advanced VLSI Technologies and Devices (3-0-0-3) 3 Credits

Faculty Coordinators : (Dr. R. K. Nahar); Dr. G. Eranna

Overview of VLSI technology; Effect of scaling on MOS devices and interconnections; Hot electron degradations and drain engineering structures; Process and material requirements for VLSI devices; Advanced thin-film deposition and VLSI process techniques; High-k dielectric and low-k dielectric materials; Process integration of high-k metal gate for nanoscale CMOS technology; Device characterization, failure diagnosis and reliability measurements; Carrier transport mechanisms, velocity saturation, ballistic transport; Nanoscale MOSFET, FinFET and Multi-gate FET; Emerging materials and future devices.

ASE 606 : CMOS Analog Design (3-0-0-3) 3 Credits
Faculty Coordinator : Dr. S. C. Bose

Basic concepts of transistors and diodes, their modeling, large-signal and small signal analysis, CMOS technology, clock feed-through; Reference sources : bias circuits, band-gap reference circuit, cascode current mirror; Single-stage amplifier, common source amplifier, drain and gate amplifier, differential amplifier; Operational amplifier; Comparators; Switched-capacitor circuits; Introduction to data converters; Issues of analog layout and device noise.

ASE 607 : Advanced VLSI System Architectures (3-0-0-3) 3 Credits
Faculty Coordinator : Dr. A. S. Mandal

Introduction and review of basic computer architectures, CISC and RISC processors; Pipelining, hazards, exception handling, optimization techniques, synchronous and asynchronous pipelining; Memory organization, caches, virtual memory, memory management; Arithmetic circuits, algorithms and architectures for high-radix adders, multipliers, sine-cosine and exponential computation; Instruction-level parallelism, super-scalar, super-pipelined and VLIW architectures, array and vector processors; Multiprocessor architectures and parallel architectures, synchronization, memory consistency; DSP architectures; Performance improvement techniques; ASIP; Low-power architectures; Fault-tolerant architectures; Case study on Algorithm-to-Architecture; Future trends.

ASE 608 : Optoelectronic Materials, Devices and Technologies (3-0-0-3) 3 Credits
Faculty Coordinators : Dr. C. Dhanvantri; Dr. Bala Pesala

Optoelectronic Materials; Growth of Epitaxial materials; Characterization of Epitaxial Materials; Optoelectronic Devices (Light Emitting Diodes, Semiconductor Lasers, UV, Visible and IR Photo-detectors and Receivers, Solar Cells); Compound semiconductors and advanced electronic devices; Compound Semiconductor Technologies; Packaging of compound semiconductor components; Applications and trends.

ASE 609 : Photonic Materials, Devices and Technologies (3-0-0-3) 3 Credits
Faculty Coordinators : Dr. S. Pal; Dr. Bala Pesala

Introduction to Photonics; Basic photonic components and their technologies; Propagation of Electromagnetic waves; Optical waveguides and optical fibers; Principle of optical fiber communications, Transmission capacity, Dispersion and losses in optical fiber; Coupled mode theory in guided wave systems; Materials and fabrication technologies; Types of waveguides; Basic photonics devices and components; Optical sensors and sensing techniques; Optical MEMS; Fiber gratings and waveguide gratings; Photonic crystal based waveguides and devices; Packaging of photonic devices; Applications of photonic devices; Recent trends.

ASE 621 : Characterization and Measurement Techniques Laboratory (0-1-3-2) 2 Credits
Faculty Coordinators : Dr. K. J. Rangra; Dr. J. Akhtar; Dr. G. Eranna

Laboratory practices and safety considerations; IV and CV Measurements; Resistivity, thickness, thin-film surface and bulk defects; grain size measurement; AFM/STM surface analysis; Stress and deformation measurements; Measurement of sheet resistance, junction depth, carrier mobility, doping profile estimation, minority carrier life-time measurement; Model parameter extraction experiments.

ASE 622 : MEMS Technology, LTCC and Packaging Laboratory (0-1-3-2) 2 Credits
Faculty Coordinators : Sh. B. D. Pant; Dr. Rishi Sharma; Dr. P. K. Khanna

Laboratory practices and safety considerations;; Wafer cleaning; Lithography : front and backside alignment; Bulk micro-machining; DRIE process; LPCVD; Metalization; Wafer bonding; Surface planarization; Wafer dicing; LTCC process; Packaging.

ASE 623 : Design of MEMS and Microsensors Laboratory (0-1-3-2) 2 Credits
Faculty Coordinators : Dr. Ram Gopal; Dr. K. J. Rangra

Laboratory practices and safety considerations; MEMS design tools; Design of pressure sensors of various types; Design of gas sensors of various types; Acoustic, Ultrasonic, micro-resonator, ISFET; RF MEMS design and simulation.

ASE 624 : Nanoelectronic Technologies Laboratory (0-1-3-2) 2 Credits
Faculty Coordinator : Sh. Anil Kumar

Laboratory practices and safety considerations; Fabrication of metal thin films by sputtering/e-beam/resistive-heating and measurement of film thickness by making steps using wet etching; Experiments on growth of Silicon nanoparticles and their optical characterization; Experiments with nanolithography and nanopatterning; Simulation of single electron devices using SIMON; Simulation of inverter circuit using SET in SIMON; Operation of AFM/STM; Analysis of AFM/STM images; Study of annealing effect on roughness/grain size of metal films by AFM/STM imaging and analysis.

ASE 625 : Study and Seminar on Advanced VLSI Technologies (0-1-3-2) 2 Credits
Faculty Coordinator : (Dr. R. K. Nahar); Dr. G. Eranna

This will involve literature search, review and study of current research on materials, process methodologies and simulations, and novel applications related to advanced VLSI technologies and nanoelectronics. Simulation studies and experiments may also be carried out, where possible. A study report is to be submitted and a seminar is to be given.

ASE 626 : CMOS Analog Design Laboratory (0-1-3-2) 2 Credits
Faculty Coordinators : Dr. S. C. Bose; Sh. Anil Kumar Saini

Laboratory practices and safety considerations; I-V characteristics of MOSFET, estimation of early voltage; Clock feed-through and its minimization; Bias generation architecture simulation; Band-gap reference circuit simulation; Design and simulation of various amplifiers; Design and simulation of 2-stage CMOS operational amplifier; Layout of analog circuits.

ASE 627 : HDL-based Digital Design Laboratory (0-1-3-2) 2 Credits
Faculty Coordinators : Dr. A. S. Mandal; Sh. Ravi Saini

Laboratory practices and safety considerations; Introduction to HDLs; Simulation of behavioral, Architecture/RTL, data-flow and structural HDL code; Sub-system design using HDL : various adder architectures, BCD arithmetic, various counters, traffic-light controller, *etc.*; Mini-project. (*SystemC, VHDL and/or SystemVerilog will be used as the HDL for the laboratory.*)

ASE 628 : Optoelectronic Devices and Technologies Laboratory (0-0-4-2) 2 Credits
Faculty Coordinator : Dr. C. Dhanvantri

Laboratory practices and safety considerations; Lift-off process for Ohmic Contact on GaAs substrate; TLM measurements for specific contact resistance; RIE process for GaAs etching; LI Characteristics of 980 nm Laser Diode; Transistor characteristics of GaAs Power MESFET; LED Characteristics; Photoluminescence characterization of GaN epitaxial material; Characterization of PIN-FET receiver module.

ASE 629 : Photonic Devices and Technologies Laboratory (0-0-4-2) 2 Credits
Faculty Coordinator : Dr. S. Pal

Laboratory practices and safety considerations; Measurement of refractive index and thickness of planar waveguides; Propagation loss measurement of planar waveguides; Design of 1x2 and 1x4 optical power splitter; Measurement of insertion loss, uniformity and polarization-dependent loss of a packaged 1x8 optical splitter at C+L band region; Design and simulation of Bragg gratings; Waveguide patterning by photolithography; Testing of MUX/DEMUX by DWDM test set-up; Chip-level testing: alignment of DUT (in a diced chip) to the source and the detector with x-y-z alignment stages.

ASE 651 : Project Management (2-1-0-2) 2 Credits (Same as AES 651 and MDSE 651)
Faculty Coordinator : Sh. Raj Singh

Introduction; Project formulation, evaluation and initiation; Project planning and scheduling; Resource allocation; Time management; Risk management; Project implementation; Project monitoring and control; Project closure; Project documentation; Complex projects; Advances and trends.

ASE 701 : Advanced Self-study on Special Topic (1-1-6-4) 4 Credits
Faculty Coordinators : Senior Scientists

This will involve readings from published literature or books about new frontiers on a specific topic related to the field of semiconductor electronics under guidance of senior scientist(s). A report needs to be submitted and a seminar on the special topic needs to be presented.

List of Faculty Members : Advanced Semiconductor Electronics

S. No.	Name	Designation	Discipline
1.	Dr. Chandra Shekhar	Director	Microelectronics/VLSI Design
2.	Sh. Raj Singh	Scientist G	Microelectronics/VLSI Design
3.	Dr. A. S. Mandal	Scientist F	Microelectronics/VLSI Design
4.	Dr. S. C. Bose	Scientist F	Microelectronics/VLSI Design
5.	Dr. A. Karmakar	Scientist E-II	Microelectronics/VLSI Design
6.	Sh. Ravi Saini	Scientist C	Microelectronics/Digital Design
7.	Sh. Anil Kumar Saini	Scientist C	Microelectronics/Analog Design
8.	Sh. Jai Gopal Pandey	Scientist C	Microelectronics/Digital Design
9.	Dr. V. K. Khanna	Scientist G	MEMS/IC Technology
10.	Sh. B. D. Pant	Scientist G	MEMS Technology
11.	Dr. Ram Gopal	Scientist F	MEMS Technology/Devices
12.	Dr. K. J. Rangra	Scientist F	MEMS Devices/Design
13.	Dr. Ajay Agarwal	Scientist E-II	MEMS Technology/Devices
14.	Dr. Rishi Sharma	Scientist-C	MEMS Technology/Devices
15.	Dr. P. K. Khanna	Scientist F	LTCC Technology/Packaging
16.	Dr. Nikhil Suri	Scientist C	LTCC Technology
17.	Dr. J. Akhtar	Scientist G	Semiconductor Devices
18.	Dr. R. K. Nahar	Ex-Scientist G	IC Technology
19.	Sh. Anil Kumar	Scientist F	Nanoelectronics Technology
20.	Dr. G. Eranna	Scientist F	IC Technology
21.	Sh. Jitendra Singh	Scientist C	IC Technology/Devices
22.	Dr. C. Dhanvantri	Scientist F	Optoelectronics/Photonics
23.	Dr. Suchandan Pal	Scientist E-II	Optoelectronics/Photonics
24.	Dr. Bala Pesala	Scientist E-I	Optoelectronics/Photonics