Model Curriculum

QF Name: ADVANCED PROGRAM ON NANOSCIENCE AND NANOTECHNOLOGY

QF Code:

QF Version:

NSQF Level: 6.5

Model Curriculum Version:

Electronic Sector Skill Council of India || 155, 2nd Floor, ESC House, Okhla Industrial Area - Phase 3, New Delhi – 110020

Table of Contents

Training Parameters

Sector	Electronics
Sub-Sector	Research in Semiconductor devices
Occupation	High End research and development (Academic & Industry)/ Faculty in the Nanoelectronics, Microsystems, smart materials technologies, and related areas
Country	India
NSQF Level	6.5
Aligned to NCO/ISCO/ISIC Code	
Minimum Educational Qualification and Experience	Masters and above (Any engineering/ science background)
Pre-Requisite License or Training	NA
Minimum Job Entry Age	On an average 22
Last Reviewed On	NA
Next Review Date	
NSQC Approval Date	
QF Version	
Model Curriculum Creation Date	
Model Curriculum Valid Up to Date	
Model Curriculum Version	
Minimum Duration of the Course	90
Maximum Duration of the Course	90

Program Overview

This section summarizes the end objectives of the program along with its duration.

Training Outcomes:

• At the end of the program, the learner should have acquired the listed knowledge and skills:

• As an objective to extend the facilities available at the nanocentre for research and process/product development, the hands-on training program encourages the learner to become equipped with the following skillsets as a leverage:

Compulsory:

- Introduction to the research infrastructure available at the Nano Centers in the form of hands-on training. These would provide in-depth information about the equipment and their capabilities.
- Introduction to the research infrastructure available at the Nano Centers in the form of lab tours. This would provide an overview about the labs and equipment that are in-use for the processes.
- Hands-on training for each process step. These would provide in-depth information about the lab samples, equipment and their capabilities as well as other requirements.
- Expert talks on the nanoelectronics/semiconducting material by the faculty members and expert speakers.
- Hands-on training on Fabrication modules, such as, introduction to Wet Etch Bay, Furnaces, Introduction to Thin Films, Lithography, Dry Etch, RCA cleaning, Diffusion, PSG etching, Front/ back Metal Deposition, Photoresist stripping, Forming gas annealing
- Hands-on training on Characterization tools, such as, Probe Station, FTIR & Zeta PALS, AFM, LDV, XRD, Raman, SEM, XPS, TEM, Solar Simulator, Quantum Efficiency.
- Hands on training on some of the simulations like TCAD, COMSOL, etc.
- Study of the relevant literature for the in depth understanding of the various processes and equipment.
- Preparation and presentation of the research proposal.
- Self-assessment of the knowledge acquired by organizing an MC Quiz.

Compulsory Modules:

• The table lists the modules and their duration corresponding to the Compulsory NOS of the QF.

NOS and Module Details	Theory Duration (In Hours)	Practical/OJT Duration (In Hours)	On-the-Job Training Duration (in hours) (Mandatory)	On-the-Job Training Duration (in hours) (Recommended)	Total Duration (In Hours)
Module 1 (Introduction to Facilities/ Equipment)	06:00	00:00	00:00	00:00	06:00

NOS Version No.	06:00	00:00	00:00	00:00	06:00
Module 2 (Hand-on training on Fabrication modules)	20:00	00:00	00:00	00:00	20:00
NOS Version No.	20:00	00:00	00:00	00:00	20:00
Module 3 (Hands-on training on Characterization tools)	30:00	00:00	00:00	00:00	30:00
NOS Version No.	30:00	00:00	00:00	00:00	30:00
Module 4 (HW/Reading material)	20:00	00:00	00:00	00:00	20:00
NOS Version No.	20:00	00:00	00:00	00:00	20:00
Module 5 (Preparation of Research Proposal)	10:00	00:00	00:00	00:00	10:00
NOS Version No.	10:00	00:00	00:00	00:00	10:00
Module 6 (Research Proposal presentation)	03:00	00:00	00:00	00:00	03:00
NOS Version No.	03:00	00:00	00:00	00:00	03:00
Module 7 (MC Quiz)	01:00	00:00	00:00	00:00	01:00
NOS Version No.	01:00	00:00	00:00	00:00	01:00

OJT	00:00	00:00	00:00	00:00	00:00
Total Duration	90:00	00:00	00:00	00:00	90:00

Module Details

Module 1: Introduction to Facilities/ Equipment
Bridge Module
Terminal Outcomes:

- Explain the basic concepts of nanotechnology/ nanoelectronics/ semiconductor
- Describe various use cases of nanotechnology/ nanoelectronics/ semiconductor
- Introduction to the research infrastructure available at the Nano Centers in the form of lab tours and hands-on training.

Duration: 06:00 hrs
Theory - Key Learning Outcomes
• Introduction to the research infrastructure available at the Nano Centers in the form of lab tours and hands-on training. • These would provide in-depth information about the equipment and their capabilities. • These would provide in-depth information about the different labs, equipment and their capabilities as well as other requirements.
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/Laptops • Notepad and pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 2: Hands-on training on Fabrication modules

Bridge Module

Terminal Outcomes:

- Understanding of various Fabrication modules such as Wet Etch Bay, Furnaces, Introduction to Thin Films, Lithography, Dry Etch, RCA cleaning, Diffusion, PSG etching, Front/ back Metal Deposition, Photoresist stripping, Forming gas annealing, etc.

Duration: 20:00 hrs
Theory - Key Learning Outcomes
• Introduction and Hands-on training on various Fabrication modules - Lab safety protocols - RCA cleaning - Deposition tools - Oxidation furnace, thermal evaporators, Sputter Systems, Electron Beam Evaporators, Plasma Laser Deposition System, Atomic Layer Deposition Systems, ICPCVD, HWCVD - Lithography tools - Laser writer, photolithography systems, E-Beam lithography - Etch tools - DRIE, STSRIE, Plasma Etcher, Plasma Asher, Forming gas annealing, - Doping tools: PDS, PIII - Wet Etch Bay - Packaging tools - wire bonder, wafer dicer
Tools, Equipment and Other Requirements
Labs equipped with the following: Tools mentioned above (as per the Institute-wise) • PCs/Laptops • Notepad and pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 3: Hands-on training on Characterization tools

Bridge Module

Terminal Outcomes:

- Understanding of various Characterization tools, such as, Probe Station, FTIR & Zeta PALS, AFM, LDV, XRD, Raman, SEM, XPS, TEM, Solar Simulator, Quantum Efficiency, etc.

Duration: 30:00 hrs
Theory - Key Learning Outcomes
• Introduction and Hand-on training on Characterization tools, such as, - Electrical Characterization: Probe Station for IV/CV measurements - Mechanical Characterization: LDV - Material Characterization: XRD, XPS - Optical Characterization: FTIR, UV-Vis, Raman, PL, Zeta PALS - Surface/morphological characterizations - AFM, SEM, FESEM, TEM - Opto-electronics characterization - Solar Simulator, Quantum Efficiency - Electro - Magnetic properties: Polytronic Research Electromagnet Model, PPMS, SQUID, Hall measurement system
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/Laptops • Notepad and pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 4: HW/Reading material

Bridge Module

Terminal Outcomes:

- Advanced understanding of various processes and equipment nanotechnology/ Nanoelectronics
- Advanced understanding of Semiconductor Technology

Duration: 20:00 hrs
Theory - Key Learning Outcomes
• Study of the relevant literature for the in depth understanding of the various processes and equipment as well as novel devices. Overview of nano centres at the Institute **Processes:** • Thin Film Deposition • Lithography process • Plasma assisted etching processes • Deep Reactive Ion Etching • Plasma Doping System • X-ray Photoelectron Spectroscopy Analysis • Mask Designing Using Clewin Software • Unique 2D and 3D Zeiss Microscopy Solutions using X-Ray microscopy **Simulation:** • Modeling Microfluidics using COMSOL • Semiconductor Modeling using COMSOL • TCAD **Devices:** • MOSCAP devices/ MIM Capacitors • Microfuidic devices for healthcare applications • Nanomaterials and devices • Inter-digitated Electrodes for Biosensors • Impedance based biosensor • A MEMS based Explosive Trace Detector • 2D MOS2 devices • Spintronic devices • Anisotropic Magnetoresistance devices • GaN LED • Microheaters • Cantlilever
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/Laptops

- Chart paper and sketch pens
- Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 5: Preparation of Research Proposal

Bridge Module

Terminal Outcomes:

- Gaining knowledge on how to submit a good research proposal.
- Outcome of a good research proposal can lead to publication in the peer-reviewed journals and filing a patent.

Duration: 10:00 hrs
Theory - Key Learning Outcomes
• How to write the research proposal • Writing the technical process clearly • Outcome of the research proposal • Problem statement is addressed clearly • Proof of concept/ Innovative idea
Classroom Aids:
• Whiteboard and Markers • Chart paper and sketch pens • LCD Projector and Laptop for presentations
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/Laptops • Notebook and pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 6: Research Proposal Presentation

Bridge Module

Terminal Outcomes:

- Summarizing a research proposal in a concise form.
- Platform to show-case the proposed research work to reviewers and participants.
- Technical discussions which will lead to improvising the research problem.

Duration: 03:00 hrs
Theory - Key Learning Outcomes
• How to prepare a poster • How to present a poster • Feasibility check of the research proposal • Handling the cross questioning
Classroom Aids:
• Whiteboard and Markers • Chart paper and sketch pens • LCD Projector and Laptop for presentations
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/Laptops • Notebook and pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Module 7: MC Quiz

Bridge Module

Terminal Outcomes:

- Enhancing technical aptitude.
- Assessment of the understanding of the concepts taught during the lectures.

Duration: 01:00 hrs
Theory - Key Learning Outcomes
• Understanding the concepts taught during lectures
Classroom Aids:
• Whiteboard and Markers • Chart paper and sketch pens • LCD Projector and Laptop for presentations
Tools, Equipment and Other Requirements
Labs equipped with the following: • PCs/ Laptops • Notebook and sketch pens • Internet with Wi-Fi (Min 2 Mbps dedicated)

Annexure

Trainer Requirements

Trainer Prerequisites						
Minimum Educational Qualification	**Specialization**	**Relevant Industry Experience**		**Training Experience**		**Remarks**
		Years	**Specialization**	**Years**	**Specialization**	
Doctorate in Science & Engineering	Electrical/ Physics	~3	Semiconductor technology	~3	Semiconductor technology	

Trainer Certification	
Domain Certification	**Platform Certification**

Assessor Requirements

Assessor Prerequisites						
Minimum Educational Qualification	**Specialization**	**Relevant Industry Experience**		**Training/Assessment Experience**		**Remarks**
		Years	**Specialization**	**Years**	**Specialization**	
Doctorate in	Electrical/	~3	Semiconductor	~3	Semiconductor	

Science & Engineering	Physics		technology		technology	

Assessor Certification	
Domain Certification	**Platform Certification**

Assessment Strategy

1. Assessment System Overview:
   - Batches assigned to the assessment agencies for conducting the assessment on SDMS/SIP or email
   - Assessment agencies send the assessment confirmation to VTP/TC looping SSC
   - Assessment agency deploys the ToA certified Assessor for executing the assessment
   - SSC monitors the assessment process & records

2. Testing Environment:
   - Confirm that the centre is available at the same address as mentioned on SDMS or SIP
   - Check the duration of the training.
   - Check the Assessment Start and End time to be as 10 a.m. and 5 p.m.
   - If the batch size is more than 30, then there should be 2 Assessors.
   - Check that the allotted time to the candidates to complete Theory & Practical Assessment is correct.
   - Check the mode of assessment—Online (TAB/Computer) or Offline (OMR/PP).
   - Confirm the number of TABs on the ground are correct to execute the Assessment smoothly.
   - Check the availability of the Lab Equipment for the particular Job Role.

3. Assessment Quality Assurance levels / Framework:
   - Question papers created by the Subject Matter Experts (SME)

- Question papers created by the SME verified by the other subject Matter Experts
- Questions are mapped with NOS and PC
- Question papers are prepared considering that level 1 to 3 are for the unskilled & semi-skilled individuals, and level 4 and above are for the skilled, supervisor & higher management
- Assessor must be ToA certified & trainer must be ToT Certified
- Assessment agency must follow the assessment guidelines to conduct the assessment

4. Types of evidence or evidence-gathering protocol:

   - Time-stamped & geotagged reporting of the assessor from assessment location
   - Centre photographs with signboards and scheme specific branding
   - Biometric or manual attendance sheet (stamped by TP) of the trainees during the training period
   - Time-stamped & geotagged assessment (Theory + Viva + Practical) photographs & videos

5. Method of verification or validation:

   - Surprise visit to the assessment location
   - Random audit of the batch
   - Random audit of any candidate

6. Method for assessment documentation, archiving, and access

   - Hard copies of the documents are stored
   - Soft copies of the documents & photographs of the assessment are uploaded / accessed from Cloud Storage
   - Soft copies of the documents & photographs of the assessment are stored in the Hard Drives

References

Glossary

Term	Description
Key Learning Outcome	Key learning outcome is the statement of what a learner needs to know, understand and be able to do to achieve the terminal outcomes. A set of key

	learning outcomes will make up the training outcomes. Training outcome is specified in terms of knowledge, understanding (theory) and skills (practical/OJT application).
Training Outcome	Training outcome is a statement of what a learner will know, understand and be able to do **upon the completion of the training**
Terminal Outcome	Terminal outcome is a statement of what a learner will know, understand and be able to do **upon the completion of a module**. A set of terminal outcomes help to achieve the training outcome.
National Occupational Standard	National Occupational Standard specify the standard of performance an individual must achieve when carrying out a function in the workplace
Persons with Disability	Persons with Disability are those who have long-term physical, mental, intellectual, or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others

Acronyms and Abbreviations

Term	Description
QF	Qualification File
NSQF	National Skills Qualification Framework
NSQC	National Skills Qualification Committee
NOS	National Occupational Standards
SSC	Skill Sectors Councils
NASSCOM	National Association of Software & Service Companies
NCO	National Classification of Occupations
ISO	International Organization for Standardization
SLA	Service Level Agreement
IT	Information Technology
CRM	Customer Relationship Management
PC	Performance Criteria

PwD	Persons with Disability
SOP	Standard Operating Procedure