QUALIFICATION FILE-Standalone NOS

Essentials of Device Characterization and Testing

☐ Horizontal/Generic ☐ Vertical/Specialization

☐ Upskilling ☐ Dual/Flexi Qualification ☐ For ToT ☐ For ToA

☐General ☐ Multi-skill (MS) ☐ Cross Sectoral (CS) ☒ Future Skills ☐ OEM

NCrF/NSQF Level: 4.5

Submitted By:

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Section 1: Basic Details

<table>
<tr><td>1.</td><td>NOS-Qualification Name</td><td colspan="2">Essentials of Device Characterization and Testing</td></tr>
<tr><td>2.</td><td>Sector</td><td colspan="2">Electronics</td></tr>
<tr><td>3.</td><td>Type of Qualification ☒ New ☐ Revised</td><td>NQR Code & version of the existing /previous qualification: NA</td><td>Qualification Name of the existing/previous version: NA</td></tr>
<tr><td>4.</td><td>National Qualification Register (NQR) Code & Version</td><td>NG-4.5-EH-03732-2025-V1-NIELIT</td><td>5. NCrF/NSQF Level: 4.5</td></tr>
<tr><td>6.</td><td>Brief Description of the Standalone NOS</td><td colspan="2">The Standalone NOS "Essentials of Device Characterization and Testing" focuses on understanding the fundamental techniques used to evaluate and measure the electrical properties of semiconductor devices such as diodes, transistors, and integrated circuits. This includes analyzing parameters like current-voltage (I-V) characteristics, capacitance, mobility, threshold voltage, and response time under various conditions. The goal is to ensure device performance, reliability, and functionality in real-world applications. Accurate characterization and testing are essential in research, quality control, and manufacturing to meet industry standards and design specifications.</td></tr>
<tr><td>7.</td><td>Eligibility Criteria for Entry for a Student/Trainee/Learner/Employee</td><td colspan="2">a. Entry Qualification & Relevant Experience:
<table>
<tr><th>S. No.</th><th>Academic/Skill Qualification (with Specialization - if applicable)</th><th>Required Experience (with Specialization - if applicable)</th></tr>
<tr><td>1.</td><td>3-Years Diploma in Electronics and Communication Engineering/ Electrical Engineering/ allied branches after class 10th</td><td>NA</td></tr>
<tr><td>2</td><td>3rd year of 3-Years Diploma in Electronics and Communication Engineering/ Electrical Engineering/ allied branches after class 10th</td><td>NA</td></tr>
<tr><td>3</td><td>1st year of UG in Electronics Engineering/Physics/ allied fields</td><td>NA</td></tr>
<tr><td>4</td><td>12th Pass</td><td>1.5 year experience in ESDM Sector.</td></tr>
<tr><td>5</td><td>10th pass plus 2-year NTC in relevant field of Electronics Sector</td><td>1.5-year experience in ESDM Sector.</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>8.</td><td>Credits Assigned to this NOS-Qualification, Subject to Assessment (as per National Credit Framework (NCrF))</td><td>2 Credits</td><td>9. Common Cost Norm Category (I/II/III) (wherever applicable): Category-I</td></tr>
<tr><td>10.</td><td>Any Licensing Requirements for Undertaking Training on This Qualification (wherever applicable)</td><td colspan="2">NA</td></tr>
<tr><td>11.</td><td>Training Duration by Modes of Training Delivery (Specify Total Duration as per selected training delivery modes and as per requirement of the qualification)</td><td colspan="2">☒Offline ☐Online ☐Blended
<table><tr><th>Training Delivery Modes</th><th>Theory (Hours)</th><th>Practical (Hours)</th><th>Total (Hours)</th></tr><tr><td>Classroom (offline)</td><td>30</td><td>30</td><td>60</td></tr></table></td></tr>
<tr><td>12.</td><td>Assessment Criteria</td><td colspan="2"><table><tr><th>Theory (Marks)</th><th>Practical (Marks)</th><th>Project (Marks)</th><th>Viva (Marks)</th><th>Total (Marks)</th><th>Passing %age</th></tr><tr><td>100</td><td>60</td><td>20</td><td>20</td><td>200</td><td>50</td></tr></table>The centralized online assessment is conducted by the Examination Wing, NIELIT Headquarters.
*Assessment strategy shall be as per NIELIT Norms prevailing at times.</td></tr>
<tr><td>13.</td><td>Is the NOS Amenable to Persons with Disability</td><td colspan="2">☒ Yes ☐ No
Leprosy Cured Person, Dwarfism, Thalassemia, Hemophilia, Hearing Impairment (Hard of Hearing), Acid Attack Victims.</td></tr>
<tr><td>14.</td><td>Progression Path After Attaining the Qualification, wherever applicable (Please show Professional and Academic progression)</td><td colspan="2">MEMS Backend Fabrication Engineer -> Semiconductor Fabrication Engineer</td></tr>
<tr><td>15.</td><td>How participation of women will be encouraged?</td><td colspan="2">Participation by women can be ensured through Government Schemes. Occasionally, exclusive batches for women would be run for the proposed courses. Funding is available for women’s participation under other schemes launched by the Government from time to time.</td></tr>
<tr><td>16.</td><td>Other Indian languages in which the Qualification & Model Curriculum are being submitted</td><td colspan="2">Qualification file is available in English and Hindi languages.</td></tr>
<tr><td>17.</td><td>Is similar NOS available on NQR-if yes, justification for this qualification</td><td colspan="2">☐ Yes ☒ No URLs of similar Qualifications:</td></tr>
</table>

18.	**Name and Contact Details Submitting / Awarding Body SPOC** *(In case of CS or MS, provide details of both Lead AB & Supporting ABs)*	**Name:** Sh. Saket Saurabh **Email:** srv.saket@nielit.gov.in **Contact No.:** 011-25308300 **Website:** https://www.nielit.gov.in **Name:** Sh. Ashwin Pawar **Email:** ashwin.pawar@nielit.gov.in **Contact No.:** 9425361315 **Website:** https://www.nielit.gov.in	
19.	**Final Approval Date by NSQC: 18.02.2025**	**20. Validity Duration: 3 Years**	**21. Next Review Date: 18.02.2028**

Section 2: Training Related

1.	**Trainer's Qualification and experience in the relevant sector (in years)** *(as per NCVET guidelines)*	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control and allied branches with 2 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design. Or M.Sc. in Physics/Electronics/Material Science and allied branches; with 2 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design.
2.	**Master Trainer's Qualification and experience in the relevant sector (in years)** *(as per NCVET guidelines)*	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control and allied branches with 3 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design. Or M.Sc. in Physics/Electronics/Material Science and allied branches; with 3 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design.
3.	**Tools and Equipment Required for Training**	☒ Yes ☐No Available at Annexure-II
4.	**In Case of Revised Qualification, Details of Any Upskilling Required for Trainer**	NA

Section 3: Assessment Related

1.	**Assessor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control and allied branches with 3 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design. Or M.Sc. in Physics/Electronics/Material Science and allied branches 3 years of relevant experience in the field of Semiconductor Manufacturing / Semiconductor Fabrication and Packaging/VLSI Design.
2.	**Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	The assessor carries out theory online assessments through the remote proctoring methodology. Theory examination would be conducted online, and the paper comprise of MCQ. Conduct of assessment is through trained proctors. Once the test begins, remote proctors have full access to the candidate's video feeds and computer screens. Proctors authenticate the candidate based on registration details, pre-test image captured and I- card in possession of the candidate. Proctors can chat with candidates or give warnings to candidates. Proctors can also take screenshots, terminate a specific user's test session, or re-authenticate candidates based on video feeds.
3.	**Lead Assessor's/Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	External Examiners/ Observers (Subject matter experts) are deployed including NIELIT scientific officers who are subject experts for evaluation of Practical examination/ internal assessment / Project/Presentation/ assignment and Major Project (if applicable). Qualification is generally B.Tech.
4.	**Assessment Mode** *(Specify the assessment mode)*	Centralized online examination will be conducted
5.	**Tools and Equipment Required for Assessment**	☒ Same as for training ☐ Yes ☐ No *(details to be provided in Annexure-if it is different for Assessment)*

Section 4: Evidence of the Need for the Standalone NOS

1.	Government /Industry initiatives/ requirement (Yes/No): Yes
2.	Number of Industry validation provided: The course has been developed in collaboration with TATA Electronics to support the development of skilled manpower for the upcoming semiconductor industry.
3.	Estimated number of people to be trained: 500
4.	Evidence of Concurrence/Consultation with Line/State Departments (In case of regulated sectors): NIELIT is recognized as AB and AA under Government Category. NIELIT is an HRD arm of MeitY, therefore, the Line Ministry Concurrence is not required.

Section 5: Annexure & Supporting Documents Check List

Specify Annexure Name / Supporting document file name

1.	**Annexure:** NCrF/NSQF level justification based on NCrF level/NSQF descriptors *(Mandatory)*	Available at Annexure-I: Evidence of Level
2.	**Annexure:** List of tools and equipment relevant for qualification *(Mandatory, except in case of online course)*	Available at Annexure-II: Tools and Equipment
3.	**Annexure:** Industry Validation	Available at Annexure-III: Industry Validation
4.	**Annexure: Training Details**	Available at Annexure-IV: Training Details
5.	**Annexure:** Blended Learning *(Mandatory, in case selected Mode of delivery is "Blended Learning")*	Available at Annexure-V: Blended Learning
6.	**Annexure/Supporting Document:** Standalone NOS- Performance Criteria Details Annexure/Document with PC-wise detailing as per NOS format (Mandatory- Public view)	Available at Annexure-VI: Standalone NOS- Performance Criteria details
7.	**Annexure:** Detailed Assessment Criteria *(Mandatory)*	Available at Annexure-VII: Assessment Criteria
8.	**Annexure:** Assessment Strategy *(Mandatory)*	Available at Annexure-VIII: Assessment Strategy
9.	**Annexure:** Acronym and Glossary *(Optional)*	Available at Annexure-IX: Acronym and Glossary

10.	**Supporting Document:** Model Curriculum *(Mandatory – Public view)*	Available at Annexure-A: Model Curriculum

Annexure I: Evidence of Level

NCrF/NSQF Level Descriptors	Key requirements of the job role/ outcome of the qualification	How the job role/ outcomes relate to the NCrF/NSQF level descriptor	NCrF/NSQF Level
Professional Theoretical Knowledge/Process	• Understanding the fundamentals of device characterization, including electrical, optical, and thermal testing techniques. • Familiarity with advanced characterization methods like AFM, SPM, and TEM.	Provides foundational knowledge of characterization mechanisms, processes, and applications in semiconductor devices.	4.5
Professional and Technical Skills/ Expertise/ Professional Knowledge	• Proficiency in conducting I-V, C-V, and R-C measurements, thermal and reliability testing, and optical characterization. • Hands-on experience with advanced tools like ellipsometry and AFM for device analysis.	Equips learners with technical skills to operate characterization equipment, analyze data, and interpret device performance.	4.5
Employment Readiness & Entrepreneurship Skills & Mind-set/Professional Skill	• Prepared for roles such as Semiconductor Device Characterization Technician or Testing Engineer; skilled in troubleshooting, teamwork, and technical reporting.	Aligns job readiness and professional skills with industry standards, focusing on precision and innovation in testing processes.	4.5
Broad Learning Outcomes/Core Skill and Responsibility	• Accountability for conducting precise device testing, analyzing performance parameters, and integrating characterization techniques into manufacturing processes.	Prepares learners to take ownership of characterization tasks and contribute to quality control and process optimization in the semiconductor industry.	4.5

Annexure II: Tools and Equipment (Lab Set-Up)

List of Tools and Equipment

Sl. No	Description	Qty.	Specifications
1	**Classroom**	1	30 Sq. m
2	**Student Chair**	30	-
3	**Student Table**	30	-
4	**LCD Projector**	1	-
5	**Trainer Chair & Table**	1	-
6	**Pin up Board**	1	-
7	**White Board**	1	-
8	**Desktop Computer with accessories**	30	Processor: Intel Core i5 (sixth generation newer) or equivalent Memory: 16GB RAM, Internal Storage: 500GB
9	**Desk jet printer**	1	A4

List of Tools and Equipment:

Electrical Characterization Tools
- Semiconductor Parameter Analyzer
- Source Measure Units (SMU)
- LCR Meter
- Probe Station for I-V and C-V Measurements

Optical Characterization Tools
- Ellipsometer
- Reflectometer
- Photoluminescence Spectrometer

Thermal and Reliability Testing Tools
- Thermal Test Systems (Temperature Cycling and Thermal Resistance Measurement)
- Burn-In Test Equipment
- Stress Test Chambers

Advanced Characterization Tools
- Atomic Force Microscope (AFM)

- Scanning Probe Microscope (SPM)
- Transmission Electron Microscope (TEM)

General Equipment
- Desktop Computers with Analysis Software (MATLAB, Python)
- LCD Projector
- Whiteboard

Consumables
- Silicon Wafers and Test Samples
- Cleaning Solvents (Acetone, Isopropyl Alcohol)

Safety Equipment
- Personal Protective Equipment (Gloves, Goggles, Lab Coats)
- Chemical Fume Hood
- Spill Kits and Emergency Eye Wash Stations

Annexure III: Industry Validations Summary

The course has been developed in collaboration with TATA Electronics to support the development of skilled manpower for the upcoming semiconductor industry.

Annexure IV: Training & Employment Details

Training Projections:

Year	Estimated Training # of Total Candidates	Estimated training # of Women	Estimated training # of People with Disability
2025-26	**100**	**50**	**10**
2026-27	**200**	**70**	**15**
2027-28	**200**	**70**	**15**

Data to be provided year-wise for next 3 years.

Annexure V: Blended Learning

Blended Learning Estimated Ratio & Recommended Tools: NA

Annexure VI: Performance Criteria details

1. Description:

This topic covers the key methods used to study and test semiconductor devices like diodes, transistors, and integrated circuits. It focuses on measuring how these components behave electrically — such as their voltage-current relationship, switching speed, and other key performance indicators. These tests help engineers understand if a device is working correctly, how efficient it is, and whether it meets the required technical standards. Characterization and testing are vital steps in the development and production of reliable, high-performance electronic components.

2. **Scope:**

- Skill Development in Device Characterization Techniques: Equip learners with practical and theoretical knowledge of electrical, optical, thermal, and advanced characterization methods to analyze and optimize semiconductor devices for performance and reliability.

- Industry-Ready Competence: Prepare individuals for roles in semiconductor manufacturing, quality assurance, and device testing through hands-on experience with industry-standard tools and processes, fostering technical expertise and innovation.

3. Elements and Performance Criteria:

To be competent, the user/individual on the job must be able to:

Elements	Assessment Criteria for Performance Criteria/Learning Outcomes
Introduction to Device Characterization	**PC1.** Demonstrate understanding of semiconductor devices and the importance of characterization in device development and manufacturing. **PC2.** Explain key device parameters such as threshold voltage, carrier mobility, and leakage current.
Electrical Characterization Techniques	**PC3** Describe the principles of I-V, C-V, and R-C measurements and their significance in evaluating device performance. **PC4:** Perform electrical characterization, including threshold voltage and mobility measurements, using MOSFETs and diodes.

Optical Characterization Techniques	**PC5:** Explain optical characterization principles, including photoluminescence, ellipsometry, and reflectometry, and their applications in semiconductor devices. **PC6**: Conduct optical property measurements, such as film thickness, bandgap, and refractive index, using tools like ellipsometry.
Thermal and Reliability Testing	**PC7:** Demonstrate understanding of thermal management techniques and reliability testing methods such as stress testing and burn-in. **PC8**: Perform thermal conductivity measurements and analyze device reliability through stress tests and failure analysis.
Advanced Characterization Techniques	**PC9:** Explain advanced techniques like Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM), and Transmission Electron Microscopy (TEM), and their roles in surface analysis and failure detection. **PC10:** Utilize advanced tools for surface and nanostructure analysis, interpreting the results for process optimization.
Process Integration and Final Project	**PC11:** Demonstrate the integration of characterization techniques in semiconductor manufacturing processes, addressing challenges and ensuring precision. **PC12:** Design, implement, and evaluate a device characterization process as part of a final project, showcasing comprehensive technical and practical expertise.

4. Knowledge and Understanding (KU):

The individual on the job needs to know and understand:

KU1: The principles and applications of semiconductor device characterization techniques, including electrical (I-V, C-V), optical (ellipsometry, reflectometry), and thermal testing, and their significance in device development and manufacturing.

KU2: The role of device parameters such as threshold voltage, mobility, leakage current, and on/off ratios in determining device performance and reliability.

KU3: The tools and techniques used in device characterization, including advanced methods like Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM), and Transmission Electron Microscopy (TEM), for analyzing structural, electrical, and optical properties.

KU4: The challenges and solutions related to integrating characterization processes into semiconductor manufacturing, including process optimization and quality assurance.

5. Generic Skills (GS):

The user/individual on the job needs to know how to:

GS1: Identify and troubleshoot challenges in device characterization processes, applying critical thinking to optimize techniques for accurate and reliable measurement outcomes.

GS2: Communicate technical findings effectively, collaborate with cross-functional teams (e.g., process engineers, researchers, and quality analysts), and present characterization results and process optimizations clearly and concisely.

GS3: Leverage analytical and decision-making skills to evaluate characterization data, refine testing parameters, and achieve precise and reproducible device performance metrics.

GS4: Utilize documentation and reporting skills to maintain detailed records of characterization experiments, results, and analysis, ensuring traceability and quality assurance in testing workflows.

Annexure VII: Assessment Criteria

Detailed assessment criteria for each NOS/Module are as follows:

Elements	Assessment Criteria for Performance Criteria/Learning Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
Introduction to Device Characterization	**PC1.** Demonstrate understanding of semiconductor devices and the importance of characterization in device development and manufacturing. **PC2.** Explain key device parameters such as threshold voltage, carrier mobility, and leakage current.	15	10	-	-
Electrical Characterization Techniques	**PC3** Describe the principles of I-V, C-V, and R-C measurements and their significance in evaluating device performance. **PC4:** Perform electrical characterization, including threshold voltage and mobility measurements, using MOSFETs and diodes.	15	10	-	-

Optical Characterization Techniques	**PC5:** Explain optical characterization principles, including photoluminescence, ellipsometry, and reflectometry, and their applications in semiconductor devices. **PC6**: Conduct optical property measurements, such as film thickness, bandgap, and refractive index, using tools like ellipsometry.	17	10	-	-
Thermal and Reliability Testing	**PC7:** Demonstrate understanding of thermal management techniques and reliability testing methods such as stress testing and burn-in. **PC8**: Perform thermal conductivity measurements and analyze device reliability through stress tests and failure analysis.	17	10	-	-
Advanced Characterization Techniques	**PC9:** Explain advanced techniques like Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM), and Transmission Electron Microscopy (TEM), and their roles in surface analysis and failure detection. **PC10:** Utilize advanced tools for surface and nanostructure analysis, interpreting the results for process optimization.	18	10	-	-
Process Integration and Final Project	**PC11:** Demonstrate the integration of characterization techniques in semiconductor manufacturing processes, addressing challenges and ensuring precision. **PC12:** Design, implement, and evaluate a device characterization process as part of a final project, showcasing comprehensive technical and practical expertise.	18	10	20	-
Viva	Including all Elements	-	-	-	20
GRAND TOTAL		**100**	**60**	**20**	**20**

Annexure VIII: Assessment Strategy

This section includes the processes involved in identifying, gathering, and interpreting information to evaluate the Candidate on the required competencies of the program.

Assessment of the qualification evaluates candidates to ascertain that they can integrate knowledge, skills and values for carrying out relevant tasks as per the defined learning outcomes and assessment criteria.

The underlying principle of assessment is fairness and transparency. The evidence of the outcomes and assessment criteria. Competence acquired by the candidate can be obtained by conducting Theory (Online) examination.

About Examination Pattern:

1. The question papers for the theory exams are set by the Examination wing (assessor) of NIELIT HQS.

2. The assessor assigns roll number.

3. The assessor carries out theory online assessments. Theory examination would be conducted online and the paper comprise of MCQ

4. Pass percentage would be 50% marks.

5. The examination will be conducted in English language only.

Quality assurance activities: A pool of questions is created by a subject matter expert and moderated by other SME. Test rules are set beforehand. Random set of questions which are according to syllabus appears which may differ from candidate to candidate. Confidentiality and impartiality are maintained during all the examination and evaluation processes.

Annexure-IX: Acronym and Glossary

Acronym

Acronym	Description
AA	Assessment Agency
AB	Awarding Body
NCrF	National Credit Framework
NOS	National Occupational Standard(s)
NQR	National Qualification Register
NSQF	National Skills Qualifications Framework

Glossary

Term	Description
National Occupational Standards (NOS)	NOS define the measurable performance outcomes required from an individual engaged in a particular task. They list down what an individual performing that task should know and also do.
Qualification	A formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards
Qualification File	A Qualification File is a template designed to capture necessary information of a Qualification from the perspective of NSQF compliance. The Qualification File will be normally submitted by the awarding body for the qualification.
Sector	A grouping of professional activities on the basis of their main economic function, product, service or technology.