Deliverable 2.2 – Annex 4

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Annex 4

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Annex 4: Focus Groups: Needs at specific microelectronics value chain levels

1) Semiconductor design

METIS has set up a Focus group dedicated to the identification of job profiles and skills needs in the industry of semiconductor design. This chapter presents the results of this focus group.

Semiconductor design is one of the main strengths of the European microelectronics industry. Indeed, Europe remains a world leader in design in specific professional segments, primarily automotive, industrial and aeronautics, with 30 to 40% of global design activity in these segments according to DECISION Etudes & Conseil. A skilled workforce in semiconductor design is therefore crucial of Europe's competitivity.

- *Objectives*
- To pinpoint the skills that are the most critical and difficult to find in the workforce in semiconductor design.
- To give inputs for the design of training modules.

Participants to the Focus group

Organization	Field
Infineon	Large company – Semiconductor design
ST Microelectronics	Large company – Semiconductor design
NXP	Large company – Semiconductor design
Bosch	Large company – Semiconductor design
IC Sense	Mid-sized company – Semiconductor design
Melexis	Mid-sized company – Semiconductor design
Riot Micro	SME – Semiconductor design
University of South-eastern Norway (USN)	University
TU Graz	University
CEA Leti	Research & Development
Fraunhofer	Research & Development
DECISION Etudes & Conseil	Consulting firm

Educational profiles of employees in semiconductor design

Education level (EQF)	Estimated percentage
High School diploma / Baccalaureate (EQF 4)	0%
College-based higher education / apprenticeship under bachelor (EQF 5)	5%
Bachelor degree (EQF 6)	10%
Master degree (EQF 7)	70%
PhD (EQF 8)	15%
TOTAL	100%

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Skills and knowledge identified as the most sought-after and difficult to find by industrial players in the field of semiconductor design

i. College-based higher education / apprenticeship under bachelor (EQF level 5)

Table: The 5 Job profiles identified as the most sought-after by industrial players in the field of semiconductor design at EQF level 5 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)	Description
1	Electrical Test Technician	7	5	Lab/Verification & Validation Technician. Test and measure electrical performances of the device under test. Verify and validate a software or an application thanks to automated, manual, performance and tests
2	Layout / Physical Design Technician	4	5	
3	Customer Support Technician	4	3	Reproduce issues reported by customers by testing solutions
4	Measurement equipment maintenance Technician	3	3	Ensure all test equipment is operational and calibrated
5	System Design Technician	-	-	Design circuits at system level

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #1 Job Profile: Electrical Test Technician: Main skills and knowledge required

No	Skills / knowledge
1	**Cell/block/chip layout & Verification:** Is responsible for transferring hierarchical schematics into a hierarchical layout. (Cell/block level). Performs all basic checks to guarantee a correct implementation of the schematics and assures compliance with the used technology and document the results
2	**Floor planning:** Creates a floorplan of the cell/block level layout to fit the given layout constraints and the full chip floorplan. Reports risk and status to team, geometrical insight.
3	**Mastery of tools and technology:** Implements cell/block level layout, following the design rules. Knowledge of process and design specifications for qualified process and technology, tool knowledge e.g., Cadence Virtuoso and Mentor Calibre
4	**Affinity with hardware electronics**

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #2 Job Profile: Layout / Physical Design Technician: Main skills and knowledge required

No	Skills / knowledge
1	**Conduct product electrical tests**: in-circuit-tests, functional tests, burn-in tests
2	**Monitor and inspect devices under test**: recognizes and acts on failures
3	**Lean manufacturing principles, keep workplace in proper order, 5S**
4	**Advanced skills in electronics repair works, soldering, quality check**
5	**Knowledge in measurement equipment**: programmable power supplies, function generators, multimeters
6	**Developing of automated characterization test sequences**: in e.g., in LabVIEW / TestStand and or C#
7	**Debugging and coordinating of validation tests**
8	**Aligning with different domains**: e.g., software, test and development team within the project
9	**Analyzing and reporting of test results**
10	**Work pro-actively in problem solving**: debugging, focused on solutions
11	**Knowledge of scripting languages** (e.g., python)

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #3 Job Profile: Customer Support Technician: Main skills and knowledge required

No	Skills / knowledge
1	**Competencies in Analogue Electronics**
2	**Competencies in Digital Electronics**
3	**Proficient with RF Test Equipment** - Network Analyzers, Spectrum Analyzers and Signal generators
4	**Analytic & Problem-Solving Skills**
5	**Cooperate with System integration- and designers**

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #4 Job Profile: Measurement equipment maintenance Technician: Main skills and knowledge required

No	Skills / knowledge
1	**Health-check**: Calibrates, tests and inspects equipment
2	**Supervision of test equipment**: Maintains, prevents and repairs test machines
3	**Update and maintain product reliability testing data**
4	**Keep and enforce health and safety regulations at test area**
5	**Lean manufacturing principles, keep workplace in proper order, 5S**

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #5 Job Profile: System Design Technician: Main skills and knowledge required

No	Skills / knowledge
1	**RTL coding**
2	**HW description language**: VHDL, Verilog, System Verilog
3	**Scripting**
4	**Digital verification flows and tools**
5	**IC design tools**: e.g., Cadence

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: Other Job profiles in the field of semiconductor design at EQF level 5 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

The profiles in the table below are less sought-after by the industry than the 5 main job profiles described above. However, the three first profiles in the table below are identified by the focus group as critical for companies today and very hard to find on the European job market: Embedded software Technician, Radio Frequency System technician and analog design technician. The job profiles "Quality test technician" and "PCB layout Technician" are also identified as quite critical for companies and relatively difficult to find today in the European job market.

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	Embedded software Technician / Firmware Technician	10	9
2	RF System Technician	10	8
3	Analog Design Technician	10	8
4	Quality Test Technician	5	3
5	PCB Layout Technician	3	4

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

ii. Bachelor degree (EQF 6)

Table: The 5 Job profiles identified as the most sought-after by industrial players in the field of semiconductor design at EQF level 6 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)	Description

No				
1	Test engineer	8	8	Also named "Component verification & validation engineer" or "Lab / Verification & Validation Engineer". Verifies and validates a software or an application thanks to automated, manual, performance and other tests.
2	Software engineer	8	7	Also named "Embedded software engineer" or "Firmware engineer". Codes and tests software. Is responsible for the complete software development lifecycle: Coding state-of-the-art embedded software.
3	Digital designer	8	6	Also named "Digital design engineer".
4	Layout / Physical Design Engineer	6	7	Also named "Analog Layout Engineer" or "Layout Design Engineer". Creates a set of CAD drawings containing physical layers representation of an electronic circuit. Is responsible for converting an electrical design to a mask layout used for chip fabrication. Mainly analog, mixed-signal and top-level layout.
5	PCB designer	6	5	Also named "Hardware designer" or "PCB Designer & Test engineer". Designs and tests PCB.

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #1 Job Profile: Test engineer: Main skills and knowledge required

No	Skills / knowledge
1	**Developing of automated characterization test sequences**: e.g., in LabVIEW/TestStand and or C#
2	**Debugging and coordinating of validation tests**
3	**Aligning with different domains**: e.g., software, test and development team within the project
4	Analyzing and reporting of test results
5	**Work pro-actively in problem solving**: debugging and focusing on solutions
6	**Knowledge of scripting languages** (e.g., python)

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Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #2 Job Profile: Software engineer: Main skills and knowledge required

No	Skills / knowledge
1	**Understand source code management tools:** Such as Git, and the workflows associated with them (branching and merging)
2	**Develop software code**: In C, Visual C, C++, C#, .NET, Java, JavaScript, Python, Matlab
3	**Conduct unit and integration tests:** Validates the software implementation, creates test strategies, approaches, test scenarios and test ideas
4	**Familiar with Agile software development practices and tools**: Scrum processes, ASPICE compliant developing
5	**Execute design, development and testing of software components**
6	**Software design**: Objected oriented, structure/procedural, functional, imperative programming, fundamental design principles behind a scalable application design definition, implementation and debugging on microcontrollers
7	**Familiar with databases**: e.g., SQL, big data technologies (e.g., Spark, Dask), machine learning techniques

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #3 Job Profile: Digital designer: Main skills and knowledge required

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	**Concept/ Top Level Design**: Knowledge of specific methods and tools to implement models for building blocks present in low to medium complexity projects. Have conceptual knowledge of the full project, including sensor models. Have a detailed understanding of digital design techniques and memories. Knows the requirements for digital design regarding testability, coverage, timing, etc. Is able to perform risk assessment on analog-to-digital interface. Is proficient with analogue and digital electronic design, RF design, power supply design. Knowledge in analytical tools such as ETAP, schematic, spice simulation	10	10
2	**Top Level Simulation**: Creation and optimization (i.e., simulation time...) of models needed for top level mixed signal verification. Creates testbenches needed for full chip validation. Assesses the functionality of the analog/digital interface. IS able to assess the testability of the design: knowledge of MMF, ATPG, delay test, scan	10	10

No	Skills / knowledge	Level of criticality	Level of difficulty
	chain, etc. Is able to create supporting blocks and dedicated stimuli files needed for top level validation		
3	**Design Implementation**: Is able to build the top-level schematic, integrating the digital and the analog. Is able to keep the documentation/specification up to date with the actual implementation. Knows and follows guidelines regarding naming, hierarchy, design checklists, etc. to assure efficient design reuse. Knowledge of advanced cadence simulations. RTL coding, HW description language (VHDL, Verilog, System Verilog). Scripting, digital verification flows and tools, IC design tools (e.g., Cadence)	10	10
4	**Design Review**: Is able to present the performed mixed signal simulations during the design review	10	10
5	**Layout and back annotation**: Knowledge of influence of layout parasitic on mixed signal simulations (i.e., digital back annotation). Is able to support layout integration of the digital	10	10
6	**Power management innovations**: Conversion, power harvesting solutions, etc.	8	9
7	**Communication protocols**: Knowledge in communication protocols/hardware interface, such as RS232, RS485, CAN Ethernet, USB, SPI, I2C, Flash, EEPROM, ADC/DAC, WiFi/Bluetooth	7	7
8	Design for Test (DFT) Techniques	7	7

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #4 Job Profile: Layout / Physical Design Engineer: Main skills and knowledge required

No	Skills / knowledge
1	**Cell/block/chip layout & Verification**: Is responsible for transferring hierarchical schematics into a hierarchical layout (Cell/block level). Performs all basic checks to guarantee a correct implementation of the schematics and to assure compliance with the used technology and document the results
2	**Floor planning**: Creates a floorplan of the cell/block level layout to fit the given layout constraints and the full chip floorplan. Reports risk and status to team, Geometrical insight
3	**Mastery of tools and technology**: Implements cell/block level layout, following the design rules. Knowledge of process and design specifications for qualified process and technology, tool knowledge e.g., Cadence Virtuoso, Mentor Calibre
4	**Affinity with hardware electronics**

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #5 Job Profile: PCB designer: Main skills and knowledge required

No	Skills / knowledge	Level of criticality	Level of difficulty

		(1 to 10)	to fill. (1 to 10)
1	**Proficient in Analogue Electronics**	7	9
2	**Proficient in Digital Electronics**	7	7
3	**Proficient with analogue and digital electronic design**: RF design, power supply design. Knowledge in analytical tools such as ETAP, schematic, spice simulation. Have an understanding of hardware description languages, e.g., VHDL	6	6
4	**Familiar with design for manufacturing**: Design for assembly, design for test, design for inspection approaches, optimize complex and advanced designs for manufacturability	3	5
5	**Execute design, development and testing of hardware components**	3	4

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: Other Job profiles in the field of semiconductor design at EQF level 6 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

The profiles in the table below are less sought-after by the industry than the 5 main job profiles described above. However, the two first profiles in the table below are identified by the focus group as critical for companies today and very hard to find on the European job market: RF system technician and analog design engineer. The job profiles "Customer support engineer" and "Test engineer" are also identified as quite critical for companies and relatively difficult to find today in the European job market.

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	RF System Technician	10	8
2	Analog Design Engineer	10	8
3	Customer support engineer	5	5
4	Test Engineer	4	4

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

iii. Master degree (EQF 7)

Table: The 5 Job profiles identified as the most sought-after by industrial players in the field of semiconductor design at EQF level 7 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)	Description
1	Product Architect	9	10	Also named "Concept engineer" or "System architect" or "Hardware/Software system architect" or "System development engineer". Creates the required design and related documentation of the relevant design area (System level Modeling and Validation) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.
2	System designer	9	8	Also named "Analog / Mixed-signal engineer" or "RF IC design engineer". Defines and creates the required design and related documentation of the relevant design area (analog and mixed-signal design) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.
3	Digital designer	9	7	Also named "Digital design engineer". Creates the required design and related documentation of the relevant design area (digital design) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.
4	Software engineer	9	7	Also named "Embedded software engineer" or "Firmware engineer" or "Software lead designer". Create the required design and related documentation of the relevant design area (SW design) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.
5	Mixed-signal test engineer	9	7	Also named "Mixed-signal verification engineer". Verifies the required design (mixed signal) and creates the related documentation, based on a defined verification plan. Creates the required design and related documentation of the relevant MEMS elements in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #1 Job Profile: Product architect: Main skills and knowledge required

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	**System Level Modeling and Validation**	10	10
2	**Leading system level problem solving**	10	10
3	**Complex data analysis**	10	10
4	**Integration of different components of system:** Deep knowledge in semiconductor and electronics assembly technologies, competence in related quality standards (e.g., IPC)	9	8
5	**Skills related to connectivity:** 5G, 6G, RF, IoT communication architectures	8	9
6	**Familiar with Agile Hardware & Software development practices and tools, Scrum processes**	7	7

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #2 Job Profile: System designer: Main skills and knowledge required

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	**Concept/ Top Level Design**: Knowledge of specific methods and tools to implement models for building blocks present in low to medium complexity projects. For low to medium complexity projects, have conceptual knowledge of the full design, including digital, memories, sensor models. Is able to perform risk assessment on block level. Knowledge of block level and/or sub-system design specification including validation and coaching of design implementation tasks. Ensure the coherence of different building blocks	10	10
2	**Top Level Simulation**: Creates testbenches needed for full chip validation	10	10
3	**Design Review:** Is able to present designed chip and to perform simulations during the design review	10	10
4	**Layout and back annotation:** Is able to simulate a schematic including layout extracted parasitic. Advanced knowledge of technology and parasitic. Knowledge of external factors influencing floorplan and top-level layout (grounding strategy, temperature gradients, etc.). Knowledge of Design Rules impacting top level layout and floorplan. Is able to estimate area of blocks at concept design	10	10

No	Skills / knowledge		
5	**Design Implementation:** Is able to implement low to medium complexity analog building blocks while taking into account all external influences. Knowledge of the requirements of other subprocesses on the design implementation: i.e., Design for reliability Design for test Design for FA, etc. Have an understanding of ESD and EMC and knows and follow guidelines regarding both issues. Is able to estimate design time needed for blocks present in low to medium complexity projects. Is proficient with analogue and digital electronic design, RF design, power supply design. Knowledge in analytical tools such as ETAP, schematic, spice simulation. Has an understanding of hardware description languages, e.g., VHDL, experience with Cadence and/or Synopsys tools. Domains: low-power/high-voltage/high-sensitive/RF/NFC, modeling on IP- and subsystem level	9	9
6	**Design for Test (DFT) Techniques:** Test concept definition for parametric and functional tests (production test and device diagnosis), design for testability and yield improvement	8	8
7	**Power management innovations**: Conversion, power harvesting solutions, etc.	8	7
8	**Soft skills:** Provides project stakeholders with information relevant to or intended to influence decisions on development delivery	8	7
9	**Design Verification:** Verification strategy, test bench setup, AMS verification	-	-

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #3 Job Profile: Digital designer: Main skills and knowledge required

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	**Concept/ Top Level Design**: Knowledge of specific methods and tools to implement models for building blocks present in low to medium complexity projects. Have conceptual knowledge of the full project, including sensor models. Have a detailed understanding of digital design techniques and memories. Knows the requirements for digital design regarding testability, coverage, timing, etc. Is able to perform risk assessment on analog-to-digital interface. Is proficient with analogue and digital electronic design, RF design, power supply design, knowledge in analytical tools such as ETAP, schematic, spice simulation.	10	10
2	**Top Level Simulation**: Creation and optimization (i.e., Simulation time, etc.) of models needed for top level mixed signal verification. Creates testbenches needed for full chip validation. Assessment of the functionality of the analog/digital interface. Is able to assess the testability of the design: knowledge of MMF, ATPG, delay test, scan	10	10

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
	chain, etc. Is able to create supporting blocks and dedicated stimuli files needed for top level validation		
3	**Design Implementation**: Is able to build the top-level schematic, integrating the digital and the analog. Is able to keep the documentation/specification up to date with the actual implementation. Knows and follows guidelines regarding naming, hierarchy, design checklists, etc. to assure efficient design reuse. Knowledge of advanced cadence simulations. RTL coding, HW description language (VHDL, Verilog, System Verilog). Scripting, digital verification flows and tools, IC design tools (e.g., Cadence)	10	10
4	**Design Review**: Is able to present the performed mixed signal simulations during the design review	10	10
5	**Layout and back annotation**: Knowledge of influence of layout parasitic on mixed signal simulations (i.e., digital back annotation, etc.). Is able to support layout integration of the digital	10	10
6	**Power management innovations**: Conversion, power harvesting solutions, etc.	8	9
7	**Communication protocols**: Knowledge in communication protocols/hardware interface, such as RS232, RS485, CAN Ethernet, USB, SPI, I2C, Flash, EEPROM, ADC/DAC, WiFi/Bluetooth	7	7
8	Design for Test (DFT) Techniques	7	7

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #4 Job Profile: Software engineer: Main skills and knowledge required

No	Skills / knowledge	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)
1	**Knowledge on programming languages**: e.g., C, C++, Python, C#, Java, Matlab, JavaScript, .NET, Visual C, etc. Object oriented, structural/procedural, functional, imperative programming	10	10
2	**Knowledge on building technologies**	10	10
3	**Knowledge on digital systems**	10	10
4	**Knowledge on RTOS**	10	10
5	**Knowledge on SW development methodologies**: fundamental design principles behind scalable application design definition	10	10
6	**Knowledge on verifications methods**	10	10
7	**Advanced debug capabilities**: Implementation and debugging on microcontrollers	10	10
8	**Knows how to perform verifications reviews**	10	10
9	**Security/Cybersecurity by design**	8	9
10	**Identifying risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure**	7	5

No	Skills / knowledge		
11	**Databases:** Familiar with databases (e.g.: SQL) big data technologies, (e.g., Spark, Dask)	-	-

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: #5 Job Profile: Mixed-signal test engineer: Main skills and knowledge required

No	Skills / knowledge
1	**Concept/ Top Level Design**: Knowledge of specific methods and tools to implement models for building blocks present in low to medium complexity projects. Has conceptual knowledge of the full project, including sensor models. Has a detailed understanding of digital design techniques and memories. Knows the requirements for digital design regarding testability, coverage, timing, etc. Is able to perform risk assessment on Analog-to-digital interface. Ensures coherence of different building blocks
2	**Top Level Simulation:** Creation and optimization (i.e., simulation time...) of models needed for top level mixed signal verification. Creates testbenches needed for full chip validation. Assesses the functionality of the analog/digital interface. Is able to assess the testability of the design: knowledge of MMF, ATPG, delay test, scan chain, etc. Is able to create supporting blocks and dedicated stimuli files needed for top level validation. Has an experience with Cadence and/or Synopsys tools
3	**Design Implementation**: Is able to build the top-level schematic, integrating the digital and the analog. Is able to keep the documentation/specification up to date with the actual implementation. Knows and follows guidelines regarding naming, hierarchy, design checklists, etc. to assure efficient design reuse. Knowledge of advanced cadence simulations
4	**Design Review**: Is able to present the performed mixed signal simulations during the design review
5	**Layout and back annotation**: Knowledge of influence of layout parasitic on mixed signal simulations (i.e., digital back annotation, etc.). Is able to support layout integration of the digital

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

Table: Other Job profiles in the field of semiconductor design at EQF level 7 (entry level).

The Entry / Junior level: No experience in a similar position, except internship(s) and apprenticeship(s).

The profiles in the table below are less sought-after by the industry than the 5 main job profiles described above. However, the five first profiles in the table below are identified by the focus group as critical for companies today and very hard to find on the European job market: Test engineer, application engineer, Layout / Physical design engineer, MEMS sensor design engineer and CAD support engineer. The job profile "PCB designer" is also identified as quite critical for companies and relatively difficult to find today in the European job market.

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill. (1 to 10)

1	**Test Engineer** / Test Development Engineer / Lab-Verification & Validation Engineer	10	10
2	**Application Engineer (Technical Marketing).** Similar to customer support engineer, developing design with customer, technical feasibility	10	10
3	**Layout / Physical Design Engineer**	10	10
4	**MEMS Sensor Design Engineer**	8	10
5	**CAD Support Engineer**	8	10
6	**PCB Designer**	-	-

Source: Focus Group on Semiconductor design. Participants: Infineon, ST Microelectronics, NXP, Bosch, IC Sense, Melexis, Riot Micro, USN, TU Graz, CEA Leti, Fraunhofer, DECISION Etudes & Conseil.

2) Semiconductor manufacturing

METIS has set up a Focus group dedicated to the identification of job profiles and skills needs in the industry of semiconductor manufacturing. This chapter presents the results of this focus group.

- *Objectives*
- To pinpoint the skills that are the most critical and difficult to find in the workforce in semiconductor manufacturing.
- To give inputs for the design of training modules.

Participants to the Focus group

Organization	Field
Infineon	Large company - Semiconductor manufacturing
ST Microelectronics	Large company - Semiconductor manufacturing
Bosch	Large company - Semiconductor manufacturing
GlobalFoundries	Large company - Semiconductor manufacturing
X-Fab	Mid-size company - Semiconductor equipment
Summa Semiconductor	SME - Semiconductor equipment

Main results

Semiconductor manufacturing corresponds to the process development (Development related to Manufacturing, including Unit Process Development, YE, etc.), fabrication, test, assembly and packaging. It excludes design and technology research & development. Another specific focus group is dedicated to semiconductor design.

Strengths in electronics production. In terms of production of semiconductors, European leaders are world champions in certain specific segments (Microcontrollers, Smart cards, SiC and GaN for power, analog and radio frequency applications). Europe has developed competencies in the wake of these strong native industries, in related existing or emerging technologies such as sensing & connectivity, MEMS/NEMS, cryptography, etc.

Table: Educational profiles of employees in semiconductor manufacturing

Education level (EQF)	Estimated percentage
High School diploma / Baccalaureate (EQF 4)	32%
College-based higher education / apprenticeship under bachelor (EQF 5)	32%
Bachelor degree (EQF 6)	10%
Master degree (EQF 7)	18%
PhD (EQF 8)	8%
TOTAL	100%

Source: Focus Group on Semiconductor manufacturing. Participants: ST Microelectronics, Infineon, Bosch, X-Fab, GlobalFoundries, Summa Semiconductor.

In France, level EQF 5 and level EQF 6 are quite similar for fresh graduate, they all start as technician and then the difference is on the career path. In Germany, on the contrary, the industry makes the distinction including in the recruiting process of fresh graduates.

In 2020, the job positions associated to the highest duration between the moment companies offer the position and the moment these positions are filled are:

- Senior Maintenance technicians (EQF 6).
- Senior Test technicians (EQF 6).
- Software Development Engineers (EQF 7).
- Shift Leaders (EQF 6).

Skills and knowledge identified as the most sought-after and difficult to find by industrial players in the field of semiconductor manufacturing

High School diploma / Baccalaureate (EQF level 4)

The tables below describe the main job profiles required in 2020 for semiconductor manufacturing at the educational level EQF 4 (High School diploma / Baccalaureate) and at the entry level. The entry level (or junior level) corresponds to a candidate for a job position with no experience in a similar position (except internship(s) and apprenticeship(s)).

Job position (by order of criticality for companies)	Associated skills and knowledge (by order of criticality for companies)
Maintenance agent: In charge of preventive maintenance.	1. Work instruction: Able to understand and perform task following the work instruction. 2. Communication: Able to communicate work in progress to next shift; Familiar with terms used to execute task given. 3. Basic maintenance technical knowledge: Able to run preventive maintenance tasks under procedures.
Operator: In charge of production, operates manufacturing equipment.	1. Work instruction: Able to understand and perform task following the work instruction; Able to identify lots to run to specific equipment group. 2. Communication: Able to communicate work in progress to next shift; Familiar with terms used to execute task given.

	3. Know how: Know what action to take when there are process/ equipment abnormalities.

Source: Focus Group on Semiconductor manufacturing. Participants: ST Microelectronics, Infineon, Bosch, X-Fab, GlobalFoundries, Summa Semiconductor.

College-based higher education / apprenticeship under bachelor (EQF level 5)

The tables below describe the main job profiles required in 2020 for semiconductor manufacturing at the educational level EQF 5 (College-based higher education / apprenticeship under bachelor) and at the entry level. The entry level (or junior level) corresponds to a candidate for a job position with no experience in a similar position (except internship(s) and apprenticeship(s)).

Job position (by order of criticality for companies)	Associated skills and knowledge (by order of criticality for companies)
Process Technician: In charge of process support.	1. Work instruction / documentation: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to run simple experiments according to pre-established plans. 2. Communication: Able to communicate work in progress to next shift; Able to write reports. 3. Process skills: Limit the impact of process hazards on the workshop and the work in progress.
Maintenance Technician: In charge of preventive and corrective maintenance.	1. Innovation: Partner in support of innovative Equipment Engineering Methods. 2. Work instruction / documentation: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to analyse equipment signals (alarms, SPC/FDC). 3. Communication: Able to communicate work in progress to next shift; Able to write reports. 4. Maintenance tasks: Able to run preventive and corrective maintenance tasks; Able to run diagnostics.
Facility Technician: In charge of facilities equipment's operation.	1. Work instruction / documentation: Able to understand and perform task following the work instruction; Able to understand and use technical documentation, Able to analyse equipment signals. 2. Communication: Able to communicate work in progress to next shift; Able to write reports. 3. Maintenance tasks: Able to run preventive and corrective maintenance tasks, Able to run diagnostics Innovation; Able to contribute to innovative procedure.
Line Control Technician: Wafer logistics and dispatching.	1. Work instruction / documentation: Able to understand the whole process flow; Able to control and to steer the manufacturing line, Able to understand the fab logistic; Able to monitor the output of manufacturing line.

	2. <u>Communication</u>: Able to communicate the logistic status; Able to write reports; Able to brief the management; Able to support the supervisor. 3. <u>Dispatching skills</u>: Logistic management knowledge; Process understanding; Know how in Capacity planning; Capacity management.
Test Technician: Failure Analysis Technician.	In charge of carrying out analytical tests (morphology, elemental composition) and analyzing electronic chip failures: 1. <u>Work instruction / documentation</u>: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to run simple experiments according to pre-established plans. 2. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports. 3. <u>Test skills</u>: Able to run analysis.

Source: Focus Group on Semiconductor manufacturing. Participants: ST Microelectronics, Infineon, Bosch, X-Fab, GlobalFoundries, Summa Semiconductor.

Bachelor degree (EQF level 6)

The tables below describe the main job profiles required in 2020 for semiconductor manufacturing at the educational level EQF 6 (Bachelor) and at the entry level. The entry level (or junior level) corresponds to a candidate for a job position with no experience in a similar position (except internship(s) and apprenticeship(s)).

Job position (by order of criticality for companies)	**Associated skills and knowledge** (by order of criticality for companies)
Senior Maintenance Technician: In charge of preventive and corrective maintenance.	1. <u>Innovation</u>: Partner in support of innovative Equipment Engineering Methods. 2. <u>Work instruction / documentation</u>: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to analyse equipment signals (alarms, SPC/FDC). 3. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports. 4. <u>Maintenance tasks</u>: Able to run preventive and corrective maintenance tasks; Able to run diagnostics.
Senior Process Technician: In charge of process support.	1. <u>Work instruction / documentation</u>: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to run simple experiments according to pre-established plans. 2. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports. 3. <u>Process skills</u>: Limit the impact of process hazards on the workshop and the work in progress.

Shift Leader	1. <u>Management</u>: Lead and develop Operator, Technicians and Engineer; Develops operational plans; Coordinates of production against targets/KPIs. 2. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports; Work and communicate with stakeholders from multiple disciplines and product teams. 3. <u>Project Management</u>: Coordinate and provide project management to short term and long-term projects; Facilitate process and production; Initiate operational improvements. 4. <u>Technical Knowledge</u>: Perform ongoing process reviews to identify issues early on; Define measurable success metrics and drive alignment for production.
Specialized Facility Technician: Facility Technician with specific skill (wastewater, automation, etc.).	1. <u>Work instruction / documentation</u>: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to analyse equipment signals. 2. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports. 3. <u>Maintenance tasks</u>: Able to run preventive and corrective maintenance tasks; Able to run diagnostics Innovation; Able to contribute to innovative procedure. 4. <u>Specific technical skills:</u> Know how in wastewater treatment, automation, chemical, etc. 5. <u>Innovation</u>: Able to contribute to innovative procedure.
Test Technician: Failure Analysis Technician.	In charge of carrying out analytical tests (morphology, elemental composition) and analyzing electronic chip failures: 1. <u>Work instruction / documentation</u>: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to run simple experiments according to pre-established plans. 2. <u>Communication</u>: Able to communicate work in progress to next shift; Able to write reports. 3. <u>Test skills</u>: Able to run analysis.

Source: Focus Group on Semiconductor manufacturing. Participants: ST Microelectronics, Infineon, Bosch, X-Fab, GlobalFoundries, Summa Semiconductor.

Master degree (EQF level 7)

The tables below describe the main job profiles required in 2020 for semiconductor manufacturing at the educational level EQF 7 (Master) and at the entry level. The entry level (or junior level) corresponds to a candidate for a job position with no experience in a similar position (except internship(s) and apprenticeship(s)).

Job position (by order of criticality for companies)	**Associated skills and knowledge** (by order of criticality for companies)

Yield / test engineer: Makes sure that yield is maximized.	1. <u>Transfer knowledge:</u> Ability to apply theoretical knowledge into manufacturing context (DOE, FMEA, SPC, etc.). 2. <u>Data analysis and IT application:</u> Can apply complex data analysis tools. 3. <u>Lead and run projects:</u> Can integrate motivate interdisciplinary teams. 4. <u>Communication:</u> Ability to negotiate and communication on business and technical topics.
Automation engineer: Integrates Manufacturing process in the IT landscape (MES, etc.).	1. <u>Software Development:</u> Ability to identify potentials and/or translate requirements of the manufacturing (Process / EQ / AMHS, etc.) into Software application w/in MES Environment, Sustain and develop new Software applications in the production Environment. 2. <u>Project Management:</u> Manage and run critical SW & HW projects. 3. <u>Teamwork & Training:</u> Ability to communicate with very different levels and internal stakeholder, can train and coach production staff.
Maintenance Engineer: Guarantees maximal uptime of the tools.	1. <u>Problem Solving</u>: Strong analytical and problem-solving skills, tenacity. 2. <u>Project Management / Lead and run projects:</u> Can integrate motivate interdisciplinary teams. 3. <u>Training & Teamwork:</u> Can train and coach production staff. 4. <u>Vendor handling</u>: Ability to negotiate and collaborate with external supplier.
Process Engineer: Runs production process within the specification / Develops Unit processes.	1. <u>Transfer knowledge:</u> Ability to apply theoretical knowledge into manufacturing context (DOE, FMEA, SPC, etc.). 2. <u>Data analysis and IT application</u>: Can apply complex data analysis tools. 3. <u>Lead and run projects</u>: Can integrate motivate interdisciplinary teams. 4. <u>Training & Teamwork</u>: Can train and coach production staff.
Manufacturing engineer: Is responsible for cycle and wafer logistics.	1. <u>Factory logistics</u>: Ability to apply theoretical knowledge into manufacturing context. 2. <u>Lead and run projects:</u> Can integrate motivate interdisciplinary teams. 3. <u>Training</u> & Teamwork: Can train and coach production staff. 4. <u>Coordination:</u> Ability to solve many problems in a short period of time.
Quality engineer: Oversees the quality of the products.	1. <u>Communication:</u> Ability to negotiate and communication on business and technical topics to external customers. 2. <u>Project Management:</u> Manage and run critical projects. 3. <u>Teamwork:</u> Ability to negotiate and integrate in an international environment. 4. <u>Goals:</u> Work focused on defined goals with a sense of urgency.

Source: Focus Group on Semiconductor manufacturing. Participants: ST Microelectronics, Infineon, Bosch, X-Fab, GlobalFoundries, Summa Semiconductor.

Recommendations for training modules

Type	Knowledge & skills
Technical	- Human-to Machine communication (Programming skills, Coding, general understanding of software architecture). - Knowledge in data science and Artificial Intelligence. - Deep understanding in statistics and data analytics. - Understanding of an industrial environment. - Understanding of working in a Cleanroom environment. - Understanding of customer interactions. - Quality Mindset and Quality methods. - Cost awareness in the decision-making process, economical mindset (ROI).
Soft	- Intercultural and personal communication. - Collaboration, Teambuilding. - Resources Management.
Transversal	- Better communication skills in English. - Provide practical experience.

3) Semiconductor manufacturing equipment

METIS has set up a Focus group dedicated to the identification of job profiles and skills needs in the industry of semiconductor manufacturing equipment. This chapter presents the results of this focus group.

- *Objectives*
- To pinpoint the skills that are the most sought-after by recruiters and difficult to find in the workforce in the field of semiconductor manufacturing equipment.
- To give inputs for the design of training modules.

Participants to the Focus group

Organization	Field
Tokyo Electron	Large company - Semiconductors equipment
EMD Performance Materials (Merck)	Large company - Semiconductors equipment
Edwards	Large company - Semiconductors equipment
Physical Electronics	Mid-size company - Semiconductors equipment
Dresden Chip Academy	VET
University of York and Bristol	University
SEMI	Industry Association
DECISION Etudes & Conseil	Consulting firm

Job profiles identified as the most sought-after and difficult to find by industrial players in the field of semiconductor manufacturing equipment

No	Job profile	Level of criticality (1 to 10)	Level of difficulty to fill (1 to 10)	Minimum educational level	Comments
1	Software Engineer	High	High	Bachelor (EQF 6)	Algorithm and computational coding; Network infrastructure support for tooling
2	Field Applications Engineer	High	High	Bachelor (EQF 6)	Process transfer from lab to customer site; Software upgrades/diagnosis for tooling
3	Design engineer	High	High	Master (EQF 7)	Develop new hardware components/systems; Modeling for performance simulations
4	Process Engineer	Medium-high	High	Bachelor/ Master (EQF 6)	Materials process development and characterization; Equipment troubleshooting
5	Field Service Engineer	Medium-high	Medium (depending on geography)	High school (EQF 5)	Equipment and/or chemical installation/testing at customer sites; Diagnosing tool failures

Source: Focus Group on Semiconductor manufacturing equipment. Participants: Tokyo Electron, EMD Performance Materials (Merck), Edwards, Physical Electronics, Dresden Chip Academy, University of York and Bristol, SEMI, DECISION Etudes & Conseil

Skills and knowledge identified as the most sought-after and difficult to find by industrial players in the field of semiconductor manufacturing equipment

Table: #1 Job Profile: Software Engineer

No	Skills	Comments
1	Algorithm and computational coding	Programming coding for tool systems
2	Network infrastructure support for tooling	IT software support for stable systems

Table: #2 Job Profile: Field Applications Engineer

No	Skills	Comments
1	Process transfer from lab to customer site	Adaptation of best-known processes
2	Software upgrades/diagnosis for tooling	Identifying faulty coding and software patches and new release to tooling

Manufacturing equipment engineers should have sufficient knowledge on vacuum technologies and gas flow dynamics; as well as knowledge in control of equipment that need to combine mechanical engineering with electronics engineering, in order to design new and manufacturing equipment.

- **Challenge**: Mechatronics is important. In the past, the equipment sector was just in charge of tools and manufacturers were in charge of how to use the tools. How to apply those tools in manufacturing was not a question of the equipment provider. However, today, the equipment provider sells total workflow solutions rather than tools only. Equipment suppliers must understand how tools can be used by manufacturers (end users).

- **Suggestion**: The sector of semiconductor equipment needs more <u>Application engineers</u>. Equipment companies need application engineers who should have knowledge on physical and chemical knowledge, and a good understanding of the processes.

Table: #3 Job Profile: Design Engineer

No	Skills	Comments
1	Develop new hardware components/systems	Using CAD software to design new equipment and components
2	Modeling for performance simulations	Running computer simulations to predict performance of most ideal designs of tooling

Table: #4 Job Profile: Process Engineer

No	Skills	Comments
1	Materials process development	Optimizing recipes and collecting test results
2	Equipment troubleshooting	Diagnosing failure or monitoring tool performance

Recommendations for training modules

For METIS training, the target learners are:

- At entry level (no experience in a similar position, except internships and apprenticeships).

- Covering education levels with EQF 4 (High school diploma), EQF 5 (College-based higher education), EQF 6 (bachelor's degree), and EQF 7 (Master's degree).

Table: Identified knowledge or skills needed & recommendations for training modules for the workforce in the field of semiconductor equipment manufacturing

Area	Details	# of Modules	EQF level(s)	Suggested modules
Component Design	First specialization in microelectronics design, covering digital, analog or mixed-signal circuits (information processing and storage, RF and microwaves, sensors and actuators)	10	4 to 6	- Robot programming - 3D printing - Data analytics
System Design	Second specialisation in microelectronics design and engineering with a	13	5 to 7	- Data analytics

	focus on Research & Innovation (system-on-chip, system–in-package, hardware/software co-design)			
Basics of manufacturing	Trains the profile of "specialised technician" in microelectronics manufacturing (introduction to advanced materials, processing equipment, production process, testing, packaging, predictive/preventive services)	10	4 to 6	- Deeper knowledge in semiconductor processes - Introduction to AI
Key competencies & innovative thinking	Training on transversal skills and competences required by industry	10	5 to 7	- Technical presentation skills - Resilience - Problem-solving - Compliance / regulatory issues - Teamwork skills - Leadership / accountability - Project management

Source: Focus Group on Semiconductor manufacturing equipment. Participants: Tokyo Electron, EMD Performance Materials (Merck), Edwards, Physical Electronics, Dresden Chip Academy, University of York and Bristol, SEMI, DECISION Etudes & Conseil

4) Materials for semiconductors

METIS has set up a Focus group dedicated to the identification of job profiles and skills needs in the industry of materials for semiconductors. This chapter presents the results of this focus group.

- *Objectives*
- To pinpoint the skills that are the most sought-after by recruiters and difficult to find in the workforce in the field of semiconductor materials.
- To give inputs for the design of training modules.

Participants to the Focus group

Organization	Field
JSR Micro	Large company - Semiconductors materials
Okmetic	Mid-size company - Semiconductors materials
Axcelis	Mid-size company - Semiconductors materials

Semilab	Mid-size company - Semiconductors materials
Graphenea	SME – Semiconductors materials
Polish Center for Technology Development (PORT)	Research & Development
Budapest University of Technology and Economics (BME)	University
SEMI	Industry Association

Job profiles identified as the most sought-after and difficult to find by industrial players in the field of materials for semiconductors

The results are provided for candidates at the Entry / Junior level (No experience in a similar position, except internship(s) and apprenticeship(s)).

Table: European Qualifications Framework (EQF) level 4 (High School diploma / Baccalaureate)

No	Job profile	Specific Skills and Knowledge Needed
1	Maintenance technician: electrical, mechanical	Troubleshooting, reporting, managing service stock, parts, ERP system operation (computer system used to track stock, input/output materials, etc.), Diagnosing tool failures.
2	Manufacturing technician	Operation of production equipment according to process instructions, moving the material between process steps next to the step controlled by the operator.
3	CNC technician & Assembly technician	Be able to read technical drawings; follow technical documentation, follow assembly instructions, basic operation jobs on their own.
4	Quality inspectors	Quality assurance activities, product testing.
5	Customer Service Rep	Order processing/bookkeeping; processing customer orders accurately; scheduling delivery; tabulating pricing and inventory levels of products.

Source: Focus Group on Semiconductor materials. Participants: JSR Micro, Okmetic, Axcelis, Semilab, Graphenea, PORT, BME, SEMI.

Table: European Qualifications Framework (EQF) levels 5 & 6 (Bachelor or College-based higher education / apprenticeship under bachelor)

No	Job profile	Specific Skills and Knowledge Needed
1	Process Engineer	Materials process development and characterization: process instructions, SPC control, analysis of process outputs, improvements of processes, collaboration with other engineers/technicians. Equipment troubleshooting - diagnosing failure or monitoring tool performance.
2	Software Engineer	Algorithm and programming coding for tool systems. Network infrastructure support for tooling.
3	Field Applications Engineer	Process transfer from lab to customer site. Software upgrades/diagnosis for tooling.
4	Lab Supervisor	Oversight of a team of process engineers.

5	Maintenance engineer	Prioritization of key projects.
5	Maintenance engineer	Design and execution of maintenance schedules and tasks.
6	Quality engineer	Customer claims, SPC, coordinate quality assurance tasks, FMEAs, PDCAs, continuous improvement of processes, supplier quality (incoming material testing).

Source: Focus Group on Semiconductor materials. Participants: JSR Micro, Okmetic, Axcelis, Semilab, Graphenea, PORT, BME, SEMI.

Proposals for training modules

For METIS training, the target learners are:

- At entry level (no experience in a similar position, except internships and apprenticeships).
- Covering education levels from EQF 4 (High school diploma), to EQF 5 (College-based higher education), EQF 6 (bachelor's degree), and EQF 7 (Master's degree).

Table: Identified knowledge or skills needed & recommendations for training modules for the workforce in the field of semiconductor materials

Field	Knowledge or skills	Potential training
New technologies	New technologies, such as Machine learning, AI, Robotics and automation, play an important role in material engineering and production Knowledge needed for material engineers: • Understanding of Machine learning & AI engineer • Understanding of robotics and automation, and how to replace basic skills in production to increase competitiveness and to facilitate innovation Skills needed: • How to apply new technologies to your jobs as a material engineer	Introduction course on machine learning and AI Introduction course on robotics and automation Course giving case studies to show how to apply knowledge to solve problems
Multiple discipline	Knowledge on electronics and mechanical engineering. Everyone needs such knowledge in addition to deep knowledge in materials	Introduction on electronics and mechanical engineering
Quality engineering and management	Basic knowledge on quality engineering and methodology of quality, e.g., Quality 3.0 and 4.0 Systems Deep understanding of measurements & physical sense of statistics	Introduction on quality engineering and methodology of quality Introduction on Quality 3.0 and 4.0 systems Advanced course on measurements and physical sense of statistics

Applications	Knowledge on applications -> to be able to link specific requirements on new materials with applications (e.g., high quality of images)	Course on applications and connection between materials and applications
Soft skills	Ability to apply knowledge -> to be able to link between theory and practice	Course giving case studies to show how to apply knowledge to solve problems
	Be able creative -> training to help to think out of box	Workshop on creativity, risk taking

Source: Focus Group on Semiconductor materials. Participants: JSR Micro, Okmetic, Axcelis, Semilab, Graphenea, PORT, BME, SEMI.