

Yearly Monitoring Report 2022

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Abstract

METIS (MicroElectronics Training Industry and Skills) is a Sector Skills Alliance, co-funded by Erasmus+, implementing a strategic approach to sectoral cooperation on skills aiming to bridge the microelectronics skills gap in Europe. It is a 4-year project from November 2019 to October 2023, involving 18 partners from 13 countries, coordinated by SEMI Europe: Industrials (Infineon, Bosch, X- Fab, Arcelik, Graphenea, Summa Semiconductor, Silicon Saxony), training & education organizations (TU Graz, IMEC academy, SBH Sudost, USN, BME and IAL-FVG), social partners (WiTEC and EACG), a regulatory body (CIMEA), and a market research & intelligence firm (DECISION Etudes & Conseil).

The first step of the METIS project, in 2020, has consisted in building an EU sectoral skills strategy and a methodology to monitor and anticipate skills in the European microelectronics industry. A multi- stakeholder's approach has been adopted and 10 Focus Groups, 50 live interviews an online survey and market research have been carried out during the year 2020, leading to a first report entitled "Skills and Occupational Profiles for Microelectronics".

This report is an update of the 2020 report mentioned above. It provides a detailed description of the skills needs of the European microelectronics industry from the beginning of 2021 until 2022. It describes the new job profiles and skills which emerged during this period.

This report also describes the effects of the semiconductors' crisis, the stiff rise of investment in the microelectronic sector and the EU chips act on the recruitment policy of the sector.

Then, this report highlights the most critical¹ job profiles and skills in 2022, as well as the education level required to work in each specialization. It provides the detailed description of the 12 most critical skills looked for on the job market.

This report assesses the impact of emerging technologies on skill needs.

To conclude, this report provides policy recommendations.

¹ Both rare and very demanded on the job market.

Executive summary

A) Key evolutions since 2020

In 2022, no new job profile has emerged compared to 2020 in the microelectronic sector. But emerging skills (digital skills such as software development, data analysis and artificial intelligence skills) became more and more important for most profiles.

The global shortage of semiconductors had an immediate effect on the recruitment policy. Firms needed to hire a lot, especially profiles linked to production capacity (process engineers, process technicians, maintenance technicians). Design engineers were also demanded to adapt design to the shortage through the *design for availability*. Design for availability is about redesigning chips to get around the shortage of some parts of the value chain. This increased needs on the design side also worsen the shortage of design engineers.

The stiff rise of global investment in semiconductors also encouraged companies to hire more, thus increasing the labor shortage. In practice, the semiconductor shortage gave rise to delayed recruitment processes and delayed business plans progresses.

The EU Chips act didn't have any impact yet on skill needs in 2022. It is considered to be too early to judge.

Finally, among the technological fields that METIS monitors for impact on skills needs, "edge IoT and edge AI" is clearly the one for which an increased interest, demand, and shortage have been observed since 2020.

B) Critical job profiles in 2022

The most looked for job profiles in the EU are in 2022 as in 2020 software and design engineers. This emphasizes the place of software in the microelectronic industry.

The demand and shortage for 4 profiles have significantly raised since 2020:

- Software engineers
- Data scientists
- Experts in cybersecurity
- Application engineers

The severe shortage of senior profiles on specific topics continues

- Advanced systems architecture designers
- Senior analog designer, especially associated with strong programming skills
- Engineers experts in specific applications fields (knowledge of applications)

C) Critical skills in 2022

The most critical skills are a mix between microelectronic skills and digital skills (Machine learning and Artificial Intelligence (AI), data analytics, software skills, etc.).

- **5 key fields of skills confirmed as the most critical are (stable since 2020):**
 1. System design: SoC, SiP, complex ASICs...
 2. Artificial Intelligence / Machine learning related skills
 3. Knowledge of applications (ability to link and adapt components, materials and design constraints to specific end-user applications)
 4. Data analysis
 5. Hardware / software integration
- **The demand and shortage for 4 skills have significantly raised since 2020:**
 1. Artificial Intelligence / Machine learning
 2. Knowledge of applications
 3. Knowledge of new materials
 4. Analog design
- **Soft skills stable since 2020**
 - Overall considered as almost as important as technical skills.
 - Most critical soft skills required:
 - Teamwork & communication
 - Creativity

D) Policy recommendations in 2022

In order of number of citations by stakeholders, the policy recommendations were in 2022:

- A. Favor intra and extra-EU mobility.** This type of policy recommendations was only at the 6th place in 2020 and emerged as a priority in 2022. This is linked to the worsening of the shortage of senior profiles and the necessity for European companies to cope with it on the short term. There only solution is to hire experts from abroad, leading to a need for
- Pre- and post- arrival services for migrant workers (trainings, language trainings, logistics, networking...).
 - An ease of associated administrative procedure.
 - A lowering of the limits of teleworking from abroad.
 - A further uniformization of degrees and curriculum, especially across the EU.
- B. Introduce an EU chip academy.** This type of policy recommendations emerged since 2020 and was not present in the initial version of the METIS Skills Strategy. Stakeholders expressed their need for:
- A unified EU online training platform. Including flexible, modular (virtual / hybrid) academic training offers. This platform would also include a portfolio of microdegrees especially to answer upskilling needs from SME. A start would consist in regrouping existing trainings across the EU on a single online platform.
 - A unified EU online platform for postgraduates' job offering.
 - A unified skills monitoring system on an annual basis.
- C. Increase the involvement of the microelectronics industry in the education process.**
- D. Develop clusters and networks favoring dialog between industry and education representatives.**
- E. Communication campaigns to improve the image of the sector.**
- F. Develop joint degrees in microelectronics.**
- G. Others**

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I. Key evolutions since 2020

A. No new profile has emerged

Of the 31 stakeholders² who interviewed in 2022, 70% replied that they did not observe new profiles in the microelectronics sector. However, emerging skills are becoming more and more important for an increasing number of profiles.

The remaining 30% of the respondents who replied that they did see new profiles emerging in microelectronics mentioned either:

- Highly specialized profiles such as analog designers with strong programming skills or fab designer who can design according to Industry 4.0.
- Or profiles associated with very emerging R&D topics. More precisely, participants cited the profiles of quantum computing programmer and process engineer in new materials.

B. Emerging skills becoming more and more important for existing profiles

When asked which skills needs were developing, respondents cited:

1. Machine learning and Artificial Intelligence (AI).
2. Data analysis.
3. Systems design and system architectures (SoC, SiP, SoP, complex ASIC).
4. Digital skills and software skills (especially embedded software programming)
5. Knowledge of new materials.

The answers emphasized the need for digital skills, because of the rising automation, in almost all jobs: operators, QA engineers, application engineers...

Other skills were mentioned as gaining momentum: analog design, edge computing, environmental knowledge for product development engineers, export control know-how linked to value chains restrictions", MEMS design for high temperatures and high performance, MEMS processing / manufacturing, product marketing, programming for automatic circuit generation, low power design.

² 16% didn't reply to this question.

C. Impacts on recruiting policies

1. The global shortage of semiconductors

The Covid crisis as well as the stiff rise in the need of semi-conductors lead to a global shortage of chips that is still present today. All the supply-chain is impacted with long delays on components made with chips. Some companies even had to stop their production momentarily, waiting for critical semi-conductors to be delivered.

The main consequence on the recruitment policy of the microelectronics sector was the need of hiring more people especially focusing on the production capacities: process engineers, maintenance technicians, process technicians...

As the need of workforce was large, and the stock of workers unchanged, this led to a skills shortage, especially for senior profiles.

Companies had to deal with the shortage of semiconductors and substitute unavailable parts with available ones when possible. This process of redesigning products after a shortage is called design for availability by opposition to design for resilience. Design for resilience is about designing products with interchangeable parts in case of a shortage. But these adaptation in terms of design have only started very recently in some large companies. That is why the shortage in semiconductors impacted so harshly the whole production chain.

2. The exponential rise of global investment in semiconductor fabs

As seen in the last paragraph, the global semi-conductor shortage accentuated the shortage of workers. On the other side, the rise of investments in semiconductors' fabs had the same effect, but through a different channel: it made the recruitments possible as more money was flowing into the microelectronic sector. It also took part in the need for more workforce, as new foundries had to be built and ran to satisfy the new demand and protect the sovereignty of semiconductors' supply chain.

3. The EU chips act

70% of the participants agreed that the EU chips Act didn't have any impact on their recruitment policies. The main reason for this answer according to participants is that it is still too early to see its impact.

However, the remaining 30% of the participants did say that they are already seeing an impact of the Chips act on their recruitment policies as they need to hire more project managers and project engineers with project management skills.

II. Most critical job profiles

A. Offer vs Demand on the job market

In the last yearly monitoring report of 2020, stakeholders were asked which job profiles they considered as the most critical among 21 profiles proposed. Critical job profiles were defined as the profiles that were the most looked for and the rarest on the job market.

In this second yearly monitoring report, it was decided to ask stakeholders 2 questions instead of one to get a better insight on the critical level of each job profiles. The first question asked was about the job profiles the most looked for on the market, and the second one about the job profiles in penury.

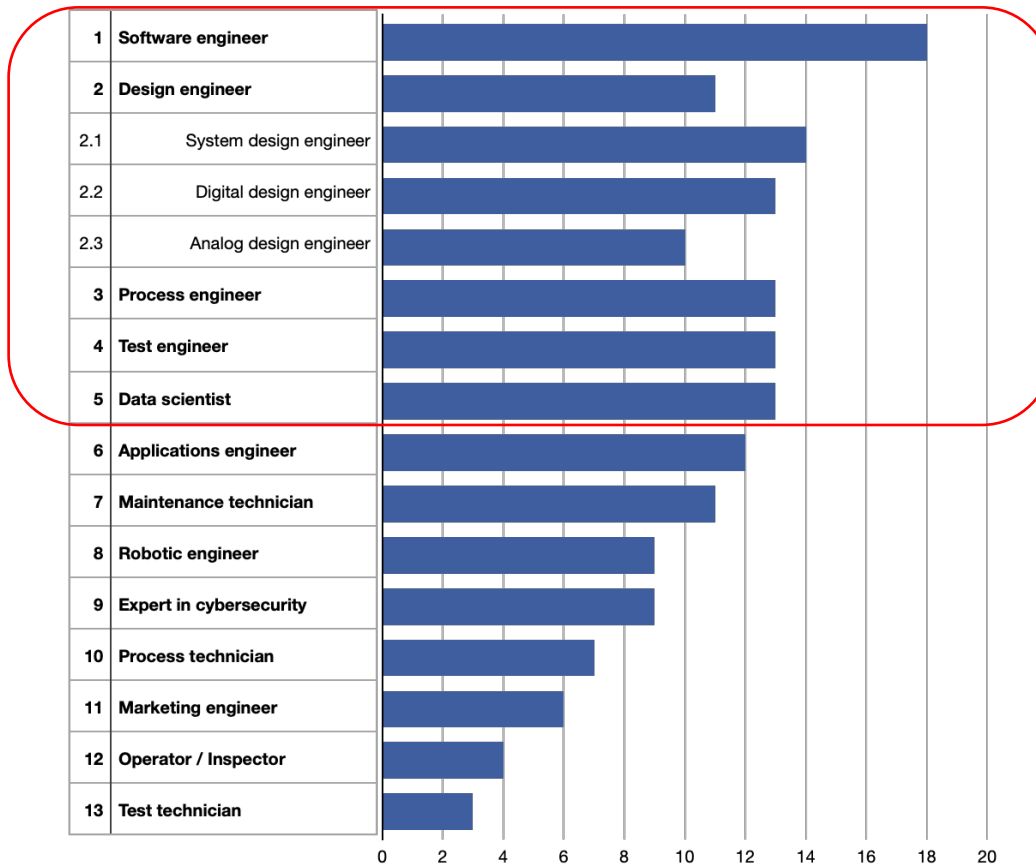
Below is a summary of the answers to both questions:

N°	Job profile	Alternative names / Description	EQF at entry level	2022: Number of stakeholders identifying the profile as one of the most sought after	2022: Number of stakeholders identifying the profile as one of the rarest
1	Software engineer	Controls and software engineer, Software developer, Solution engineer, Computer software engineer, Embedded/Firmware/Cloud software engineer, Software designer, Software design engineer	6-7	18	14
2	Design engineer	Designer	6-7	11	10
2.1	System design engineer	System designer, Product Architect, System Architect (HW/SW), System Development Engineer, HW/SW co-designer, System expert	7	14	8
2.2	Digital design engineer	Digital designer	7	13	11
2.3	Analog design engineer	Analog designer, Analog/Analog IC/Mixed-signal/ RF-IC Design Engineer	6-7	10	12
5	Data scientist	Data analyst	6-7	13	7
3	Process engineer	Manufacturing engineer	6-7	13	10
4	Test engineer	Component Verification & Validation Engineer / Lab-Verification & Validation Engineer / Field Service Engineer	6-7	13	11
6	Applications engineer	Application engineering expert, Field applications engineer, Product development engineer, Product Manager, Requirement engineer, Industry 4.0 expert, Industrial power electronics expert, Supply chain manager with basic SC material knowledge	6-7	12	11
7	Maintenance technician		5-6	11	9
9	Expert in cybersecurity	Similar to the security skills required for software engineer, but with a deeper knowledge level	7	9	8
8	Robotic engineer	Automation engineer	6-7	9	7
10	Process technician	Manufacturing technician	5-6	7	4
11	Marketing engineer	Digital Marketing expert	7	6	4
12	Operator / Inspector		5-6	4	3
13	Test technician		5-6	3	4

**2022: The 13 job profiles
identified as the most sought
after in the European
microelectronics industry**

**Number of stakeholders indicating the profile as the
most sought after:**

- From interviews / survey



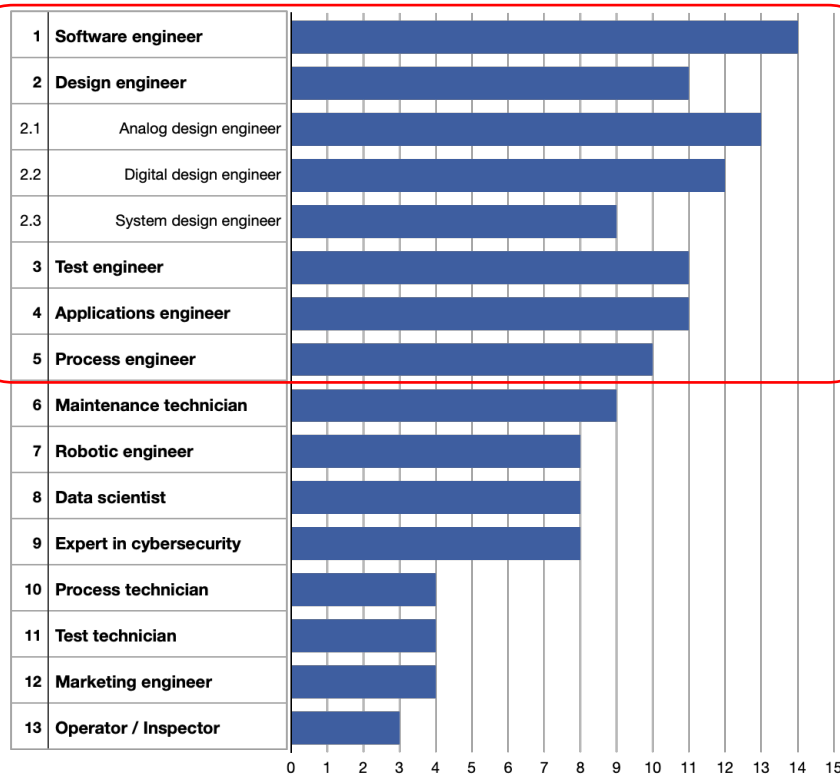
Other positions indicated as sought after by a few stakeholders:

- Specialists analog circuit generators: Combined skills of programming and AC design.
- Expert in functional safety: Special automotive position.
- Technology development and functional verification engineering.
- Optical engineers for optical metrology.
- Fab designer.
- Computer Network Architect, IT Coordinator, Network Administrator – due to growth in artificial intelligence and data.
- UX/UI Designer, SEO Specialist, HTML/CSS Writer, Content Management Specialist – New technologies, web development skills.
- Automation Engineer - to keep up with the demands of ever-shifting consumer trends.
- Web Developer - roles with specialized technical skills are consistently valued.

**2022: the 13 job profiles
identified as the most difficult to
find in the European
microelectronics industry**

**Number of stakeholders indicating the profile as the
most scarce:**

- From interviews / survey

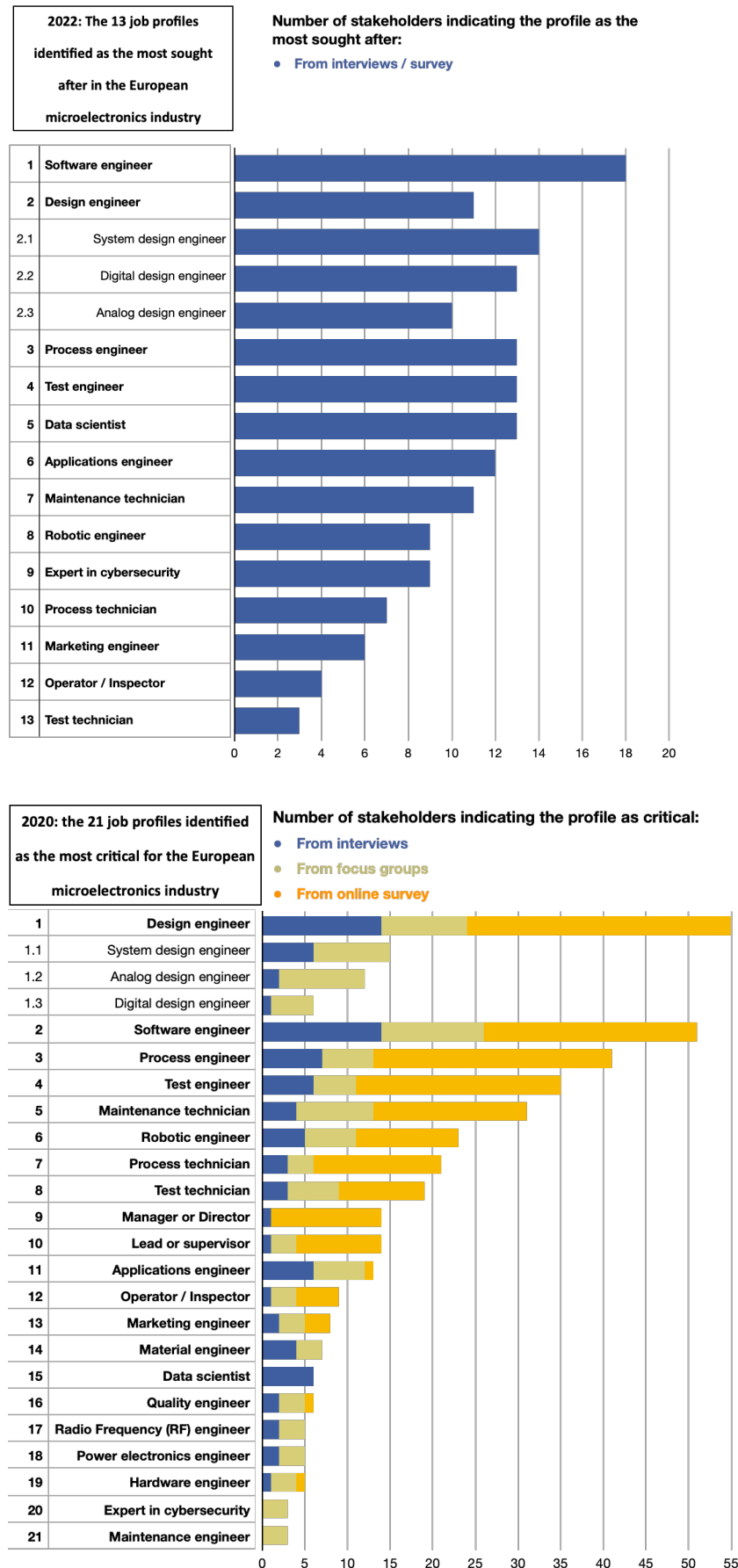


Other positions for which a few stakeholders indicated a shortage:

- Specialists analog circuit generators: Combined skills of programming and AC design.
- Expert in functional safety: Special automotive position.
- Optical design engineers.
- Fab designer.
- Technology development and verification engineering.
- Process integration engineer.
- IP/patent information officer (incl. licensing expertise), business development profiles with technical skills.
- Application architect (focused on designing IT architecture).
- Highly specialized profiles such as document management for which there is no specific education, technical project managers, automation specialist.
- Machine learning specialist.

These tables show that the job profiles the most sought for are also the ones that are the less present on the job market.

B. 2022 vs 2020: a comparison



Methodology note:

The most critical job profiles are the job profiles that are:

- The most sought-after by the industry.
- The most difficult to fill.

Just as last year's report pointed out, the job profiles the most sought after in the European microelectronics industry are software and design engineers. This confirms the growing importance of software in the microelectronics industry.

Another reason for the need of design engineers is the lack of dedicated curriculum for this role. It is then not easy to find Electrical Engineers or Information System Engineers who decide to specialize in this area.

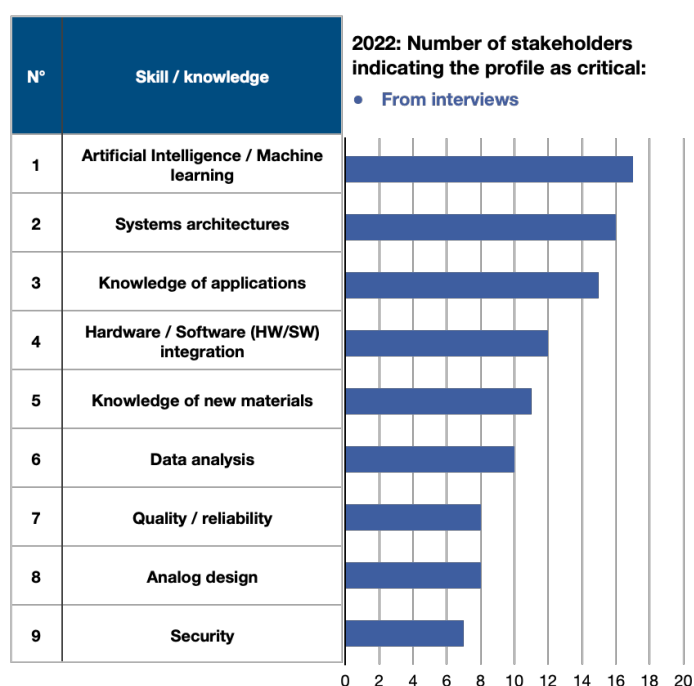
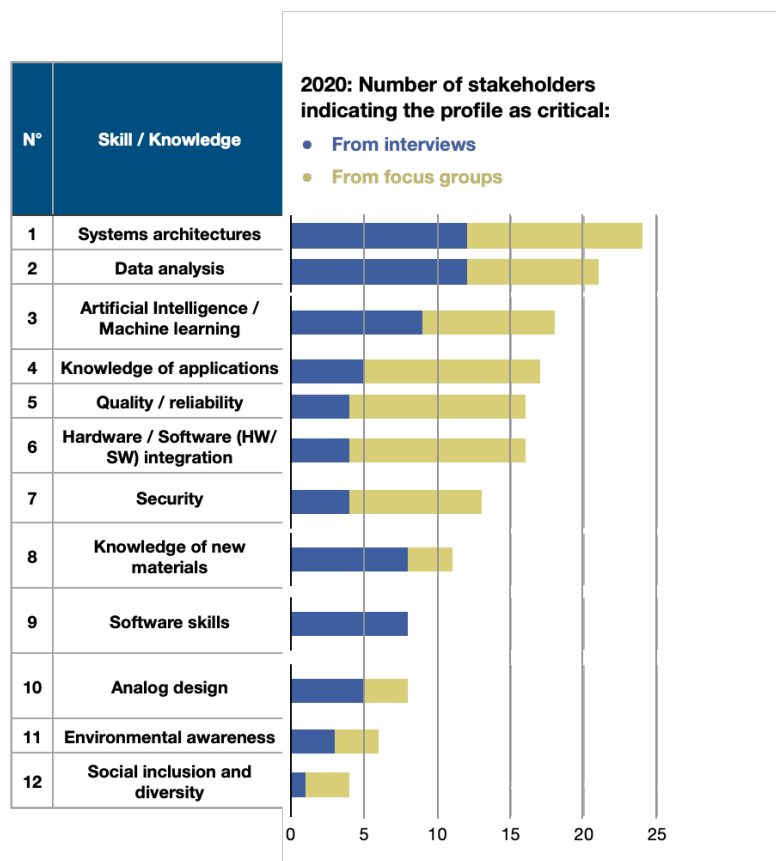
Since 2020, both the demand and shortage have significantly raised for 4 profiles:

1. Software engineers.
2. Data scientists, especially to analyze big data as smart home and IOT applications are soaring.
3. Experts in cybersecurity. This reflects the soaring risk of cyber-attacks, as well as a rising awareness of this risk.
4. Application engineers.

III. Most critical skills

A. Technical skills

This chapter summarizes the skills and knowledge identified as the most critical for the European microelectronics industry. The most critical skills and knowledge are the ones that are defined as the most sought-after by the industry and the most difficult to fill.



Other skills indicated as critical by a few stakeholders:

- Lithography.
- Metrology and TEM/SEM (= microscope technics, such as at San Joaquin Delta College in Florida).
- MEMS, microfluidics, and ultrasound, PDK modelling.
- Material sciences.
- Project management skills.

The charts above show the technical skills and knowledge described by stakeholders as the most critical for the European microelectronics industry in 2020 and in 2022. These skills and knowledge are both the most sought-after and the most difficult to find in different job profiles.

Many of these skills are associated to digitization and can be considered as digital skills:

- Data analytics.
- Artificial Intelligence / Machine learning.
- Knowledge of applications (most of emerging applications being associated to digital transition, such as ADAS³).
- Security / Cybersecurity.
- Software skills.

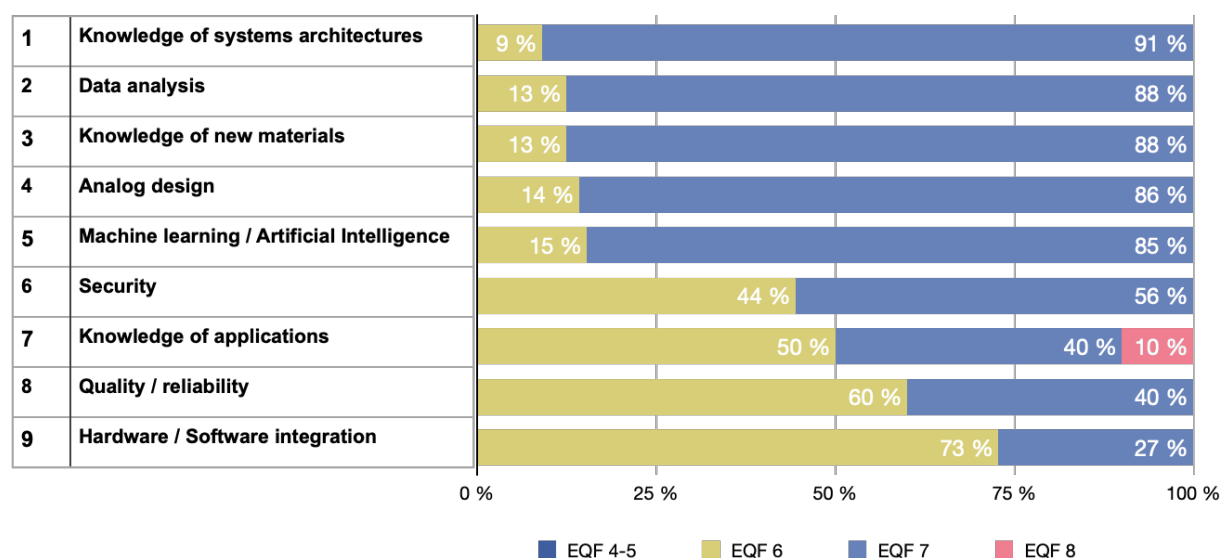
The most critical skills today are a mix between microelectronic skills and digital skills.

Since 2020, the demand and shortage for 4 fields of skills has significantly raised:

1. Artificial Intelligence / Machine learning
2. Knowledge of applications
3. Knowledge of new materials
4. Analog design

³ Advanced Driver Assistance Systems.

2022: Level of education required to work in each specialization according to stakeholders



Specializations that require the most education to enter in are the same as the most critical specializations stakeholders look for. For example, Knowledge of systems architecture require for 91% of the stakeholders at least an EQF 7 level (equivalent to a master's degree), which is the highest rate found in the results. And this is also the 2nd most critical specialization for respondents this year.

There is an obvious need for the introduction of more diplomas specialized in these critical specializations and especially the introduction of less qualified diplomas (EQF 5/6 instead of 7) to increase the workforce specialized in these critical subjects and thus satisfy microelectronics companies.

1. Machine learning / Artificial Intelligence

Knowledge and skills associated to machine learning are increasingly required for the majority of the profiles of the microelectronics industry today and will become more and more important, especially in line with the development of I4.0. These are especially important for software engineers that must be trained to a diversity of AI tools so that they have a wide view of the topic. Tools such as Keras, Torch, Tensorflow, Colab, Jupyter, Python, Lua, Matlab...

Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7.

Associated job profile:

- Main profiles concerned: Software engineers and Data scientists.
- Also, very important for Test engineers, Design engineers, Process engineers and Material engineers.
- Etc.

Content / sub-skills and sub-knowledge:

- Ability to select and use the machine learning toolsets for manufacturing (design, automation, etc.), and/or ERP.
- General introduction course on AI (at EQF 4-5): Fundamental knowledge and understanding of AI tools.
- Understanding of how to replace basic skills in production by machine learning algorithms to increase competitiveness and to facilitate innovation.
- Understanding of the impact of AI applications: It can lead to an overfitted world for citizens and engineers/developers should be aware of the consequences of their developments. Application of AI will have impacts on the job market, and social and economic development.

Beyond AI and machine learning, software skills are becoming more and more important for most microelectronics job positions: Robotic engineers, materials engineers, process engineers, power electronics engineers, RF engineers, etc. For instance, for RF and hardware engineers, software programming has become a very basic requirement in job descriptions currently. Up to the early 2000s', microelectronics technological developments were very hardware intensive (70% hardware VS 30% Software). In the early 2020s', this ratio as shift to ratio 70% for software and 30% for hardware. In certain technology (e.g., AI), software may be even more important than hardware in the semiconductor sector. However, in the semiconductor sector, many people may still not value skills in software as much as hardware, considering software skills as easier to learn which is not true as software engineering cover a very wide range of skills and knowledge.

2. System architecture

“System architecture” regroups the skills and knowledge associated to microelectronics systems: System-on-Chip (SoC), System-in-Package (SiP) and System-on-Package (SoP).

- A System-on-Chip (SoC) consists of a serie of blocks (processor, memory and caches, wireless system interfaces, network interfaces, sensor and actuators...) integrated on the same die. SoC designs also include application software and runtime systems.
- System-in-Package (SiP) has evolved as an alternative approach to SoC for electronics integration because this technology provides advantages over SoC in many market segments. In particular SiP provides more integration flexibility, faster time to market, lower R&D cost, lower NRE cost, and lower product cost than SoC for many applications. SiP is not a replacement for high level, single chip, silicon integration but should be viewed as complementary to SoC. For some very high-volume applications SoC will be the preferred approach. Some complex SiP products will contain SoC components.
- System-on-Package (SoP)⁴ goes one step beyond the other approaches in overcoming both the fundamental and integration shortcomings of SoC and SIP, which are limited by CMOS processing and the shortcomings of current packaging. While silicon technology is great for transistor density improvements from year to year, according to Moore’s Law, it is not an optimal platform for system integration of RF, optical, and certain digital components, as stated above. The SoP is akin to Moore’s Law for integrated circuits, integrating transistors: it integrates thin film components at microscale in the short term and nanoscale in the long run for mixed-signal electronic and bioelectronics systems.

Knowledge of system architectures will become more and more important especially in line with the development of IoT and I4.0. Engineers with knowledge of the systems / co-design are also more and more required for automotive applications to reduce vehicle architecture costs and increase functionality by decreasing the number of discrete components and favouring the use of standardized microelectronic components and embedded systems and platforms.

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7.

Associated job profile:

- System design engineer.
- Design engineer.
- In the absence of a System expert, teamwork between application engineers, design engineers and other engineering job profiles.

⁴ “Packaging: Past, Present and Future”, Rao R. Tummala, *Endowed Chair, Professor & Director of NSF-ERC, Packaging Research Center, Georgia, Institute of Technology, Atlanta, USA. ©2005 IEEE. 2005 6th International Conference on Electronic Packaging Technology.*

Content / sub-skills and sub-knowledge:

- Knowledge of systems architectures: system-on-chip and system-in-package. Interdisciplinary understanding of how the various system levels are interlinked and affect the overall performance.
- Understanding of the whole design and product life cycle.
- Ability to design both ICs, ASICs, systems-on-chips, system-in-package and system-on-package.
- Ability to optimize architectures.
- Ability to link and adapt design architectures to the end-using applications of systems (automotive, I4.0, etc.).

3. Knowledge of applications

Content / sub-skills and sub-knowledge:

- Ability to link and adapt technical aspects of a product (materials to use, design architecture, type of connectivity tools to integrate, etc.), to its end-user market(s) and application(s) (I4.0, automotive, etc.).
- Knowledge of applications and associated technical requirements, to build solution-oriented products.

Illustrations:

- A good knowledge of ADAS tools, other automotive developments or Industry 4.0 applications can be required for system engineer experts but also for software engineers.
- A good knowledge of automotive applications and associated technical requirements is required for the development of magnetic sensors development for the automotive industry: Safety, standards, Requirement Management and Change & Configuration Management.
- A material engineer needs to be able to link specific requirements on new materials with applications (e.g., high quality of images).

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

- Specific courses should be dedicated to specific applications. For instance, Industry 4.0 could have dedicated courses and be taught as a concept as a whole, regrouping all its associated sub-topics. On the contrary, sub-topics required for Industry 4.0 (like virtual prototyping, big data analyses, machine learning techniques, VR and AR techniques, Quality 4.0, advanced manufacturing machines) are often taught in separate curricula, even under the management of different faculties in universities, making the links between the sub-topics less clear for students. All of the relevant sub-topics could be

brought together under one curriculum, or specialization on EQF level 6-7, preferably on level 7.

Associated job profile:

- Application engineer.
- Materials engineer.
- System design engineer.
- Design engineer.
- Software engineer.

4. Hardware / Software integration

HW/SW integration is a skill depicted as very difficult to find and long to acquire (many years) by many stakeholders. Hardware and software co-design will become more and more important especially in line with the development of IoT and I4.0.

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profile:

- System design engineer.
- Design engineer.
- Software engineers.

5. Knowledge of new materials

New materials are becoming increasingly important in microelectronics: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, etc. Microelectronics engineers must have knowledge not just on traditional material engineering, but additionally on chemical and physical sciences (e.g., nanostructures).

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7. Process and material engineers graduated at EQF 6 and EQF 7 must both have received these trainings. These training are also a plus for other types of microelectronics engineers at EQF 6 and EQF 7.

The main skills and knowledge associated are:

- Knowledge of new materials: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, gallium nitride. etc. Understanding of material properties, and the need to modify the integration flow.
- Knowledge in chemical and physical sciences (e.g., nanostructures). Basic knowledge in chemistry (missing in many curricula).
- Environmental awareness associated to traditional and new materials.

- Ability to link a material with production processes, product(s) specification(s) and end-user applications.

6. Data analysis

Data analysis skills and knowledge are increasingly required for nearly all profiles of the microelectronics industry today. They are especially important for data scientists and software engineers. Several companies report a lack of software engineers with good skills in data analysis.

Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7. Every graduate at EQF 6-7 should have received initial trainings in this field.

Associated job profile:

- Nearly all profiles.
- Mainly Data scientists, Software engineers and Test engineers.
- But also, any engineer dealing with hardware: Process engineers, RG engineers, Robotic engineers, etc.
- Etc.

Content / sub-skills and sub-knowledge:

- Data management: SQL, etc.
- Data visualization: Tableau, etc.
- Data integrity: Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
- Data Security & Privacy by design: Ability to ensure security of data & data privacy. Including IP protection.
- Data analysis: Ability to interpret and make sense of large volume of data. Knowledge of potential biased conclusion led by biased data.
- Machine learning / Artificial intelligence.
- Algorithm optimization. This skill is increasingly sought-after by industrials.
- Performance Data Analysis: Analyzing performance data.

7. Quality / reliability

Knowledge associated to quality / reliability (manufacturing quality control) is more and more needed by the microelectronics industry, especially to transfer prototypes into mass production.

Meanwhile, functional safety and reliability are increasingly important within manufacturing processes. For instance, reliability and functional safety are two of the four main domains where increased skills is required for microelectronics engineers in line with the development of automotive electronics, with security and cost management (according to the focus group on automotive organized by METIS).

- Reliability: The strong impulse in the search for improving the reliability of components, systems and, in particular, designs even more than in innovation itself. This makes the system design more and more difficult and also asks for advanced testing systems to assess the reliability of the components. This implies a greater importance of test technicians and engineers and their associated skills for microelectronics companies serving the automotive industry.
- Functional Safety (Quality): Vehicle safety is an aspect linked to the improvement of reliability and led to the introduction of Functional Safety and the [ISO 26262](#).

Educational level (EQF): Associated skills and knowledge must be acquired for graduates at EQF level 7 (at EQF 6 is a plus, depending on profiles).

The main skills and knowledge associated are:

- Basic knowledge on quality engineering.
- Quality assessments (skill): Knowledge of the methodology of quality (Quality 3.0 and 4.0), and ability to use Quality tools (including quality tools associated to I4.0).
- Reliability analyses: Multidisciplinary knowledge in failure analyses, physics of failure.
- Robustness of microelectronics: Electromagnetic compatibility (EMC), electromagnetic interference (EMI), electrostatic discharge (ESD), aging, radiation hardness...
- Deep understanding of measurements and a physical sense of statistics.
- Analytical knowledge in reliability.
- Functional safety.

8. Analog design

Also named Analog / Analog IC / RF-IC Mixed-signal design (analog-to-digital converters (ADC), digital-to-analog converters (DAC)).

Analog design is one of the skills for which the European microelectronics industry face the greatest shortage currently. A progressive but very significant shortage as emerge in the industry during the past 20 years for this profile, due to the aging workforce and the lack of new graduates trained in analog design. Even though there is the trend of digitalizing signals as fast as possible, there still remains this small part of “analog”, where there are too few experts available within every company.

The shortage is particularly high for this job profile as it takes a particularly long time to develop good analog design skills and about 20 years to become good analog designer. This cannot only be done by education, but there are also many practical skills needed.

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7.

Associated job profile:

- Analog design engineer.
- Design engineer.

Content / sub-skills and sub-knowledge:

- Mixed Signal Design: Proficient with analogue and digital electronic design, noise, signal integrity, etc.

9. Security

Skills associated to Security, Cybersecurity and Security-by-design will be very important for software engineers (EQF 6-7 engineers). These skills will become more and more important in line with the development of I4.0, but also in line with automotive innovations. Security is one of the four main domains where increased skills are required in line with the development of automotive electronics (with reliability, functional safety and cost management), according to the focus group on automotive organized by METIS, especially as a tightening of the security rules applied to microelectronics in the Automotive segment is foreseen in Europe during the coming years and due to an increased external connectivity. For a Test engineer, this will become more and more important equally from SW and HW side. From the aspect of test engineering concept, the testing of security on devices themselves (code, hardware) and the closeness of a system is becoming more and more important.

Educational level (EQF): Trainings to be provided from EQF 5 to 7. Associated skills and knowledge are very important for Expert in cybersecurity / Software engineers / Robotic engineers / Process engineers / Test engineer. Associated skills and knowledge are a plus for other engineering profiles.

Associated job profile:

- Expert in cybersecurity.
- Software engineers.
- Robotics engineers.
- Process engineers.
- Test engineer.

Content / sub-skills and sub-knowledge:

- Combined knowledge between hard and software necessary.
- Security by design (Especially important for IoT and I4.0.): Know-how and applicability of secure protocols necessary.
- Skills used for cyber-physical (production) systems like diagram a network for security.
- Cybersecurity:
 - Advanced intrusion detection and prevention.
 - Advanced skills in forensics.
- Reverse engineering for the prevention of industrial spying (especially for test engineers).
- Ability to investigate the possible failures originated from improper use of malicious codes (highly for robotic engineers). Identify risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure
- Data integrity: Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
- Data Security & Privacy by design: Ability to ensure security of data & data privacy. Including IP protection.
- Safety issues.

B. Soft skills

On soft skills, the results of this yearly monitoring report confirm the results of 2020.

Soft skills are overall considered as almost as important as technical skills. This result is confirmed by a study from MIDAS (Ireland) published in 2021: *“Electronics Sector Resources Skills Needs”*. According to this report, “Engineers are typically known and hired for their advanced technical capabilities, so soft skills can sometimes be ignored, even by management in technical environments”. That is why this study calls for more soft skills training in the future.

The most critical soft skills required in 2022 are as follows:

1. **Teamwork & communication:** Topics are becoming increasingly complex, so teamwork and collaboration between teams are now crucial. The ability to summarize complex topics for non-experts is also important.
2. **Creativity:** Innovation capacity, ability to propose new ideas, new processes, new designs, to use new technologies, new applications, agile thinking.

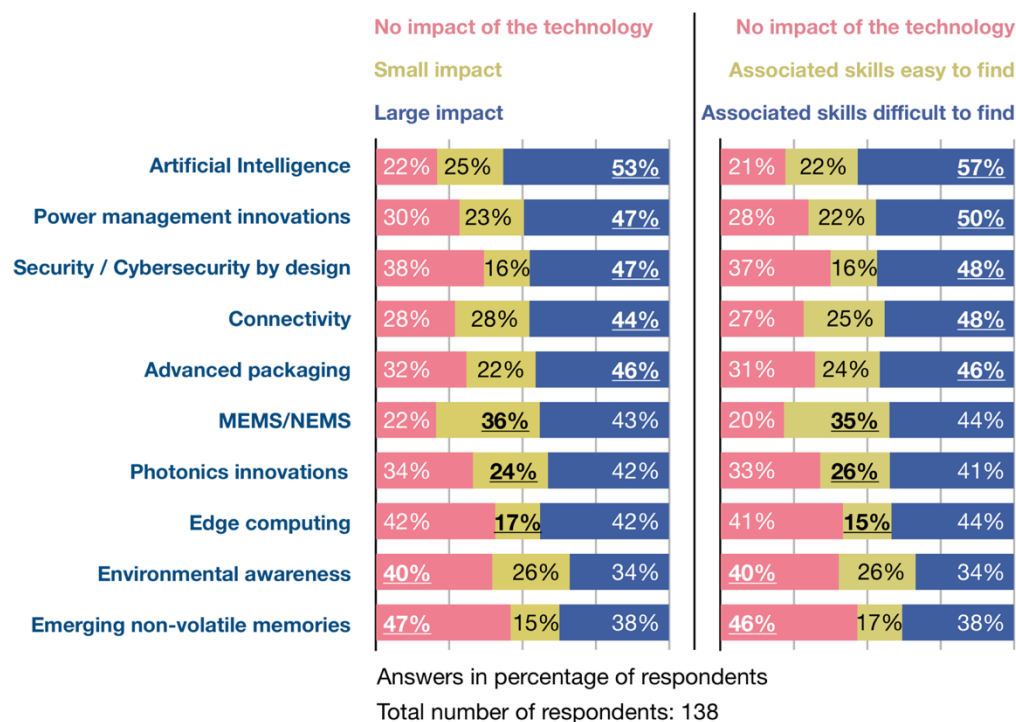
IV. Impact of emerging technologies on skills needs

The microelectronics sector and the skills required for its workers have enormously evolved in the last years due to innovation waves. This trend will carry on in the coming decades. The Moore’s Law has been the most impactful technological trend for the past 50 years, leading to cost reduction of computational power and miniaturization of microelectronics. For instance, in 2001, 8-bit microprocessors with 64 kb of memory were used in white goods. In 2011 those figures were 1 GHz for TV with 4 GB of memory. However, the Moore’s Law is coming to an end. Ever rising investment and R&D costs are required to progress in the Moore's Law and the “last node” (1 nanometer chip), should be produced by 2030. Over the coming decade and for Europe especially, innovation drivers for the microelectronic sector should come from more than Moore developments.

Technologies assessed in METIS in 2020

Technology	Description
Big data & Artificial Intelligence	Machine-learning algorithms, data management & analysis tools, associated Hardware/Software integration.
Power management innovations	Conversion, power harvesting solutions... enabling low power IC's and better energy efficiency.
Security / Cybersecurity by design	Security / Safety / Privacy issues. Hardware skills (reverse engineering, etc.). Software skills (Intrusion detection and prevention, forensics, investigation of possible failures originated from improper use of malicious codes). Ability to design a diagram of a network for security. Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
Connectivity	5G / 6G / RF / IoT communication architectures.
Advanced packaging	SiP, Fan-In, Fan-Out, WL CSP, Advanced IC substrates (Flip chip-based packages), Stacking technologies (2.5D & 3D), embedded die.
MEMS/NEMS	Micro Electro Mechanical Systems (MEMS) / Nano Electro Mechanical Systems (NEMS).
Photonics innovations	Photonics Integrated Circuits, photonic sensors, silicon photonics, photonic interconnections...
Edge computing	Bringing computation and data storage closer to the location where it is needed, to improve response times and save bandwidth.
Environmental awareness	E.g. circular economy regulatory package...
Emerging non-volatile memories	PCM (stand-alone & embedded), stand-alone MRAM, STT-MRAM (Stand-alone & embedded), RRAM (Stand-alone & embedded), nanotube RAM and Ferroelectric Non-Volatile FET).

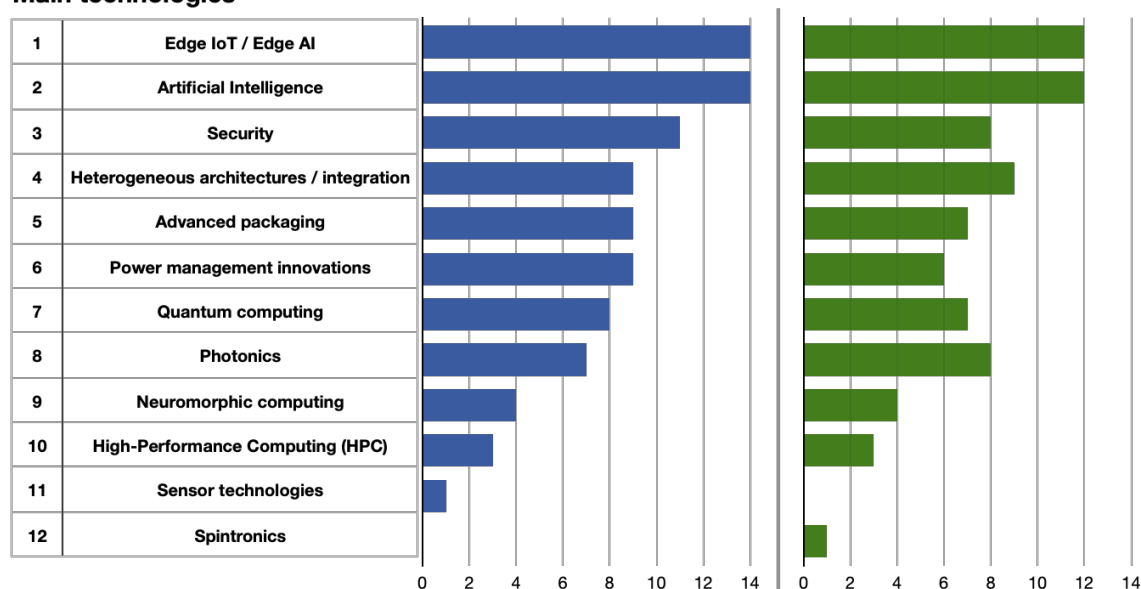
2020: Impact of the technology on the skills required for the microelectronic workforce / ease to find skills associated to each technology.



2022: Number of stakeholders indicating that the technology:

- Has an impact on the skills required for the microelectronics workforce
- Associated skills and knowledge difficult to find currently on the European job market

Main technologies



Since 2020, the main trend has been a raising impact and shortage of skills linked to the topic: Edge IoT / Edge AI.

V. Policy recommendations

This year, no stakeholder mentioned the necessity to sponsor state-of-the-art manufacturing infrastructures in the EU, which is logical given the numerous initiatives since 2020 and especially the EU chips act.

A. Favor intra and extra-EU mobility

This point came in 6th place of importance in 2020. In 2022, It is the most cited policy recommendation by respondents. The reason is simple: as seen before, the semiconductor crisis produced a major shortage in workforce, especially in the EU. To hire, European actors had no choice but to look for non-EU talents. But many factors still make it difficult for EU factories to employ non-EU citizen. To make it easier, respondents had many propositions:

Make it easier to hire non-EU citizens

- Ensure that skills assessments are undertaken as part of the pre- and post-arrival services offered to migrant workers, offer bridging training courses, including language training, to upskill potential migrant ICT specialists and provide guidance to employers wishing to recruit microelectronics workers from abroad.
- Easier access to labor market of international experts and specialists. Facilitate professionals moving into Europe (tax incentives, Visa, etc.).
- Making more efficient legal regulations and framework for employing workforce outside of the EU.
- Increase the pre-professional international accreditation of the engineering degree and the Professional Development Programs international independent accreditation (ENAAEE is strongly focused in this area).
- Remove the limits of teleworking from abroad (amendments / exceptions to tax legislative).

Uniformization of degrees across the EU

- Is still currently easier to hire locally because of the remaining differences between what universities offer in Europe, and it is difficult for companies (especially SMEs) to understand these differences between EU educational systems.

Shortage of senior profiles

- More flexibility regarding seniority of profiles – huge investment in terms of promotion of these career paths and education in required areas.
- Develop a plan on how to attract engineers with New Skills to work in the Electronics Sector, e.g., re-training.

Shortage of technicians

- Investigate an apprenticeship program to be put in place to help increase the supply microelectronics technicians on the mid-term.

B. Build an EU chip Academy

This recommendation has become very popular since 2020.

Numerous different degrees already exist in the microelectronic field in the EU. However, it can be difficult for firms, students or workers to get their way around and find the formation that best fits their needs.

The EU chip Academy would:

- Regroup existing trainings, including microdegrees, across the EU in a single online platform. This platform would be supported by a collaboration between RTO, universities and Industry.
- Propose Flexible, modular (virtual / hybrid) academic training. This could be done in a first step by putting together already existing formats, offers and buildings from universities.
- Be associated to a skills monitoring and forecasting tool: A skills monitoring system should be set up at the EU level to enhance the understanding of current and future skills needs.
- Introduce a centralized European job platform to fluidify the job market.

C. Enhance life-long learning programs and increase the involvement of the microelectronics industry in the education process

This proposition was the 1st most cited in 2020. It is the 3rd in 2022.

Lifelong learning

- Governments should develop policies and strategies on lifelong learning at the national and local levels in consultation with workers' and employers' organizations.
- Employers should fund lifelong Learning initiatives for employees, early kids' technical education could start in kindergarten, and more industry - schools cooperation should be introduced.

Courses co-designed with industry

- Examination of the current curricula contents of relevant courses of study to check potentials of "simplification" and thus to reduce the high dropout rates at universities, of course always in contact with the industry to ensure that the relevant skills are nevertheless taught.
- Education and training institutions should consult with employers' and workers' organizations on areas where curricula should be regularly updated to reflect evolving skills requirements.

- Companies should work with colleges to discuss optimum learning styles to support the Electronics Sector's future needs.

Generalize the use of experts from the industry as teachers at the university.

- Industrials should provide experts to give lectures at universities to give the students a better insight into the needed skills for working in microelectronics industry.

Internships

- Promote students' internships in the industry.
- Three to six months internships at the early stages of studies should be generalized.

Promote industry at university

- Promote our industry job variety in universities.

D. Develop clusters and networks favoring dialog between industry and education representatives

This proposition was the 3rd most cited in 2020. It is the 4th in 2022.

Such clusters and networks are required to enable universities to be in close contact with local companies to understand their needs.

More precisely, several stakeholders pledge for the organization of forums of discussions between the microelectronics industry and universities & VET representatives to identify synergies and actions at the European level. Such a forum would be in charge of:

- Setting up dedicated groups defining and updating the roadmap of skillsets needed.
- Mapping training and courses from European education providers, especially to enable SMEs to know where to recruit students for each profile. Today, large companies have the capacity to actively look for information about courses provided by universities across Europe, but it is harder for SMEs.

Other policy recommendations:

- Governments should promote coordination between ministries, authorities responsible for skilled workers, other relevant national and local governments and institutions.
- Foster a stricter interaction between Academia and microelectronics Industry.
- The electronics sector can benefit from collective thinking and cooperation on the common challenges, to address major issues like the future resource and skills needs for the sector.

E. Communication campaigns to improve the image of the sector

This proposition was the 4th most cited in 2020. It is the 5th in 2022.

The microelectronics industry suffers from a poor image as a field to work in. People should associate the microelectronics sector with Europe and not only with Silicon Valley and Taiwan or Asia. A set of initiatives should be organized to promote KETs and microelectronics to the public and attract young students.

- Make technical jobs attractive again, like maintenance technicians, operators, engineers.
- Important campaign to promote Electrical Engineering as the most important study in microelectronics.
- Allow the public to know the importance of microelectronics as the basis on which all the devices they everyday rely on are built. Let the young people know that it is not all “Apps, Social Media and software”.
- High investment into the motivation of the next generation to understand the potential and relevance of the most sought-after job profiles of this industry.
- Use more communication channels where young people are present in their free time.
- Promote EU programs to technology skills to young engineers to join in such training and on site On-the-Job-Training (OJT).
- Sector Image - Promote the Electronics Sector as a great place for people to build their career, promoting Engineering as a Profession, Electronics' positive contribution to society's needs, as well as highlighting the financial attractiveness of the sector (MIDAS Electronic Systems).

Teach microelectronics-related topics at an early stage of the education system.

- Train energy efficiency and semiconductor to high school students.
- Train more software skills at a lower education's level.
- Push digitalization in schools.

But some stakeholders are not convinced by the need for such communication efforts. According to them, students are not sufficiently attracted by the microelectronics industry in Europe because of the relatively small size of the industry compared to other regions. Therefore, according to them, **initiatives to build a stronger microelectronics value chain in Europe are the best way to attract students to microelectronics**. Especially, supports to invest in state-of-the-art large scale manufacturing capacities of processors in Europe.

F. Develop joint degrees in microelectronics

This proposition was the 5th most cited in 2020. It is the 6th in 2022.

Proposals for joint degrees / curricula for microelectronics

Fields of study	Proposals for joint degrees			
	1	2	3	4
Microelectronics / Electro-engineering / Mechanics / Mechatronics	V	V	V	V
Software / Data science / Informatics	V			
Chemistry / Material science (Polymers, etc.)		V		
Marketing, Sales and Communication			V	
Biology / Natural Science				V

As the table above shows, actors in the chips industry would like to have more interdisciplinary profiles. The table sorts by importance the different combinations of subjects. For example, the most useful joint degree would be a degree in microelectronics and software / data-science / informatics.

Typical courses linking microelectronics with chemistry and material sciences would be: Chemistry of materials for semiconductors, Physics to new semiconductor technology information...

Interdisciplinary profiles could be achieved by establishing combined study courses, by introducing other domain modules and by promoting interfaculty teaching and research exchanges.

G. Others

- **Generalize English as the training language in European Universities.**
- **Enhance diversity in the workforce.** *The microelectronics sector's talent pipeline is not diverse and inclusive enough, women participation going down from 40% to 10% along the occupational hierarchy (McKinsey & SEMI data aggregated, 2018).*
 - Recruit more women in Bachelor, Master's degree and PhD.
 - Recruit students with minority backgrounds.
 - Organize communication campaigns on diversity to high school students.
- **Impose targets linked to sustainability for the industry with deadline (e.g., 2030, 2050), such as Co2 free activities by 2050.**
- **Enhance exchange programs of students at the European and international level.**
- **Build / develop gateways for newcomers in the microelectronics industry.**
 - Facilitate student sponsorship programs so that the microelectronics industry can support scholarship (fees) of future entrants (Tax rebate, etc.).
 - Develop dedicated "gateway" programs to "fast train" non-STEM graduates.
- **Universities request to be funded by industry** money and this is not easy for the industry. Maybe policies on providing simple ways of financing Master and PhD studies.
- **Support to startups** where youth engineers attempt to do some experience on real S/C problems; they would just need support from senior experts.

VI. Annex 1 – List of European iVET and cVET providers

Organisation name	Type	Nationality	iVET	cVET
ENTER Network	Platform / Network	EU	Yes	
CEA Leti	RTO	France	Yes	
IMEC	RTO	Belgium	Yes	Yes
Leibniz Institute for High Performance Microelectronics (IHP)	RTO	Germany	Yes	
SUMCO	Company	Japan	Yes	
TU Graz	University	Austria	Yes	Yes
TU Wien	University	Austria	Yes	
Mead education	VET	Switzerland	Yes	Yes
Linkedin learning	Platform / Network	The USA	Yes	
Aalto University	University	Finland	Yes	
University of Turku	University	Finland	Yes	
Helsinki and Oulou University	University	Sweden	Yes	
VTT	RTO	Finland	Yes	
Dresden Chip Academy (SBH)	VET	Germany	Yes	Yes
Berufliches Schulzentrum für Elektrotechnik Dresden	VET	Germany	Yes	
Berufsakademie Sachsen	VET	Germany	Yes	
TU Dresden	University	Germany	Yes	
TU Freiberg	University	Germany	Yes	
TU Chemnitz	University	Germany	Yes	
Institut für Mikroelektronik Stuttgart	RTO	Germany	Yes	
Ulm University	University	Germany	Yes	
HAW Hamburg	University	Germany	Yes	Yes
FH-Westkuste	University	Germany	Yes	
Qualifizierung für Mikroelektronik Dresden GmbH (QFMD)	VET	Germany		Yes
DIU - Dresden International University	University	Germany		Yes
Education and Training Boards	VET	Ireland		Yes
MIDAS Electronic Systems Skillnet	Platform / Network	Ireland		Yes
Ecovem	Platform / Network	EU	Yes	Yes
METIS	Platform / Network	EU	Yes	Yes
Europass	Platform / Network	EU		