Shaping the
Quantum Era



POSITION PAPER ON QUANTUM TECHNOLOGIES

Prepared for the quantum age

Infineon is ready to put quantum technology potentials to work

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Jochen Hanebeck on quantum technologies



“Quantum technologies originate in the research laboratory and develop into real applications that represent tremendous potential for the economy and for society. Infineon has the crucial expertise it needs to take on a leading role in the key fields of quantum computing, quantum sensing, and post-quantum cryptography. As a trustworthy partner we connect research institutes, start-ups, and system players to lay the foundation for scalable quantum applications.

We’re not waiting for the quantum age to arrive – we’re actively shaping it today.”

Jochen Hanebeck
Chief Executive Officer, Infineon Technologies AG

Executive summary

Quantum technologies have the potential to fundamentally alter the ways in which we compute, communicate, and resolve complex challenges. These technologies open up new performance dimensions and create measurable societal and economic value, including everything from faster medication and material development to more efficient energy, mobility, and AI systems and all the way to more resilient global supply chains.

Today we are at the cusp of a global revolution based on quantum technologies. Quantum technologies are becoming central in the race for innovation in key industries such as medicine, chemistry, pharmaceuticals, logistics, IoT, and robotics, as well as the environmental and energy industries. The strategic relevance of these technologies is underscored by expected value-added potentials amounting to approximately 2 trillion US dollars by 2035.

Infineon plays an active role in this area, as a technology provider, a development and manufacturing partner, and also as a user. Infineon’s system knowledge and semiconductor expertise create the industrial basis for scalable quantum systems. At the same time Infineon makes targeted use of quantum algorithms in realizing efficiency and optimization potentials in its own activities in areas such as manufacturing, logistics, and planning.

Quantum technologies contribute to Infineon’s corporate vision “Driving decarbonization and digitalization. Together.” They enable a new dimension in digitalization with higher-performance technologies. At the same time, they accelerate innovations for more energy-efficient products, materials, and processes and in doing so make an important contribution to decarbonization.

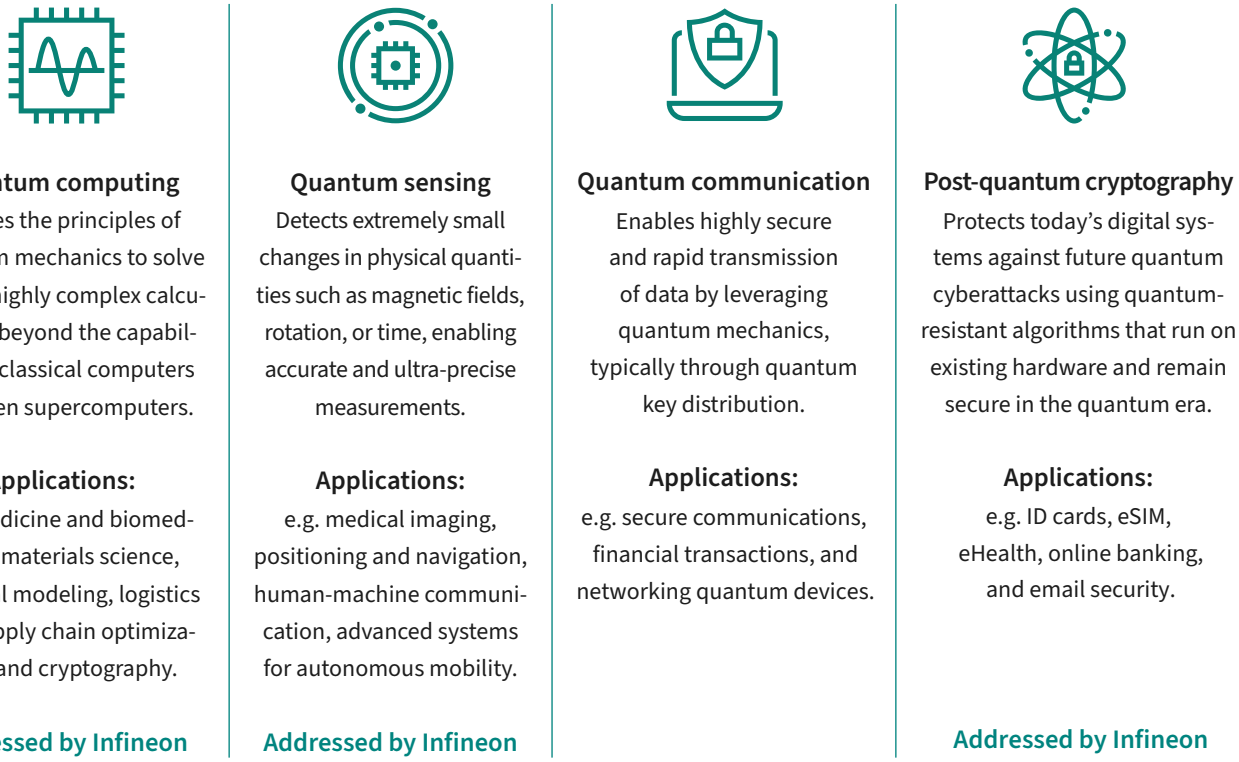
Infineon focuses on quantum computing, quantum sensing, and post-quantum cryptography – the fields with the greatest industrial levers and long-term growth potential.

Foundations of quantum technology

Quantum technologies utilize the laws of quantum mechanics. The technology is based on theories developed in the 20th century that could only be proven in practical experiments conducted decades later. These theories are based on the work of the physicists Niels Bohr (1885–1962), Erwin Schrödinger (1887–1961), Max Born (1882–1970), and Werner Heisenberg (1901–1976), among others.

Quantum mechanics describes the behavior of matter and energy at atomic and subatomic levels across the dimensions of time and space. Here physical quantities are not uniquely defined, but rather are described as probabilities (Born rule). This often serves as the basis for distinguishing two generations of quantum technologies: The first generation makes indirect use of quantum-physical effects, without specifically controlling them at the level of individual quantum states; typical examples are semiconductors, lasers, and magnetic resonance imaging (MRI), all of which are based on a fundamental understanding of quantum mechanics and are widespread today. The second generation goes even further and allows control of individual quantum systems as well as phenomena such as superposition (the simultaneous existence of more than one state) and entanglement (strong correlation of quantum states, even over great distances). This in turn makes completely novel applications possible, for example quantum computers, quantum communication, and high-precision quantum sensors, with enormous potential for science and industry.

Graphic 1 Technologies in the quantum age



Graphic 1 provides an overview of quantum technologies; Infineon is currently addressing the areas of quantum computing, quantum sensing, and post-quantum cryptography.

Quantum communication uses the laws of quantum mechanics to secure data transmission and establish interception-proof connections. Post-quantum cryptography (PQC), on the other hand, is mathematical/software-based and runs on today's hardware. Thus, PQC already protects digital documents today against cyberthreats from high-performance quantum computers of the future.

PQC is all the more relevant because attackers are already collecting encrypted data today for decryption later ("Harvest now, decrypt later"). Furthermore, digital systems (for example, cars and game consoles) are being sold today which will be in use for longer periods of time (more than ten years) and will as a result be vulnerable to future attacks by quantum computers. Early introduction of PQC procedures will protect these systems and other critical infrastructures from these threats in the future.

One thing is completely clear: Semiconductor companies play a decisive role in the industrialization of quantum technologies, combining scientific breakthroughs with the development and scalable manufacturing of marketable quantum solutions.[1]

Market potential

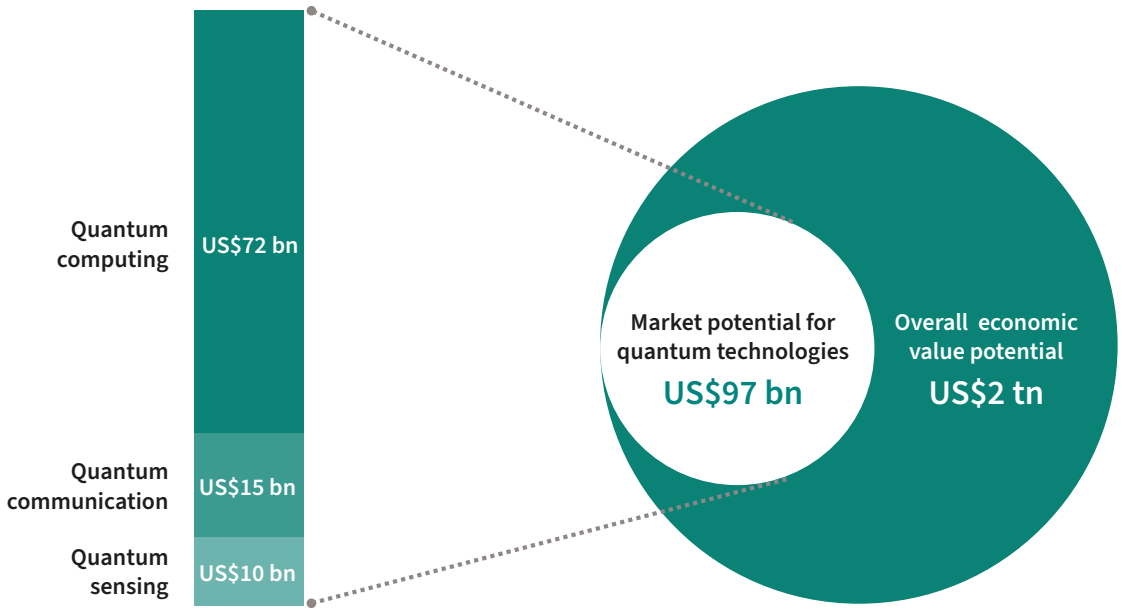
A McKinsey study (2025)[2] predicts that the worldwide market potential of the quantum technology market (computing, communication, and sensing) will grow to 97 billion US dollars by 2035.

Quantum computing accounts for the largest share of this amount, 28–72 billion US dollars, followed by quantum communication with 11–15 billion US dollars and quantum sensing at 7–10 billion US dollars. McKinsey estimates the value-added potentials to be generated by 2035 in key industries such as chemistry, biosciences, finance, and the automotive industry at as much as 2 trillion US dollars.

There is a variety of dynamic effects when it comes to the maturity of quantum technologies. The pace of development is accelerating worldwide and continues to be fueled by investments on the part of corporate, financial, and governmental players.

Graphic 2 Quantum technology market and value creation potential by 2035

Source: McKinsey Quantum Tech Report 2025



Experimental research is already utilizing quantum computers for certain highly complex applications today. Current developments are pointing the way towards hybrid computing with supercomputers and AI systems ("quantum AI"). Here, quantum computers can serve as accelerators. Thus, quantum systems can boost the performance capabilities of increasingly complex AI models, while AI is already supporting development and calibration of quantum processors. Together the two technologies unleash a mutually reinforcing potential for digital value creation.

Benefits and applications of quantum technologies

Quantum technologies make targeted use of quantum mechanical effects to unleash possible new applications with extensive economic and societal benefits; quantum technologies are considered key technologies in digital and sustainable transformation.

Graphic 3 Examples of applications in various industry sectors

Industry	Applications (excerpt)
 **Automotive & mobility**	– Quantum-driven material searches for power semiconductor substrates, electrodes and catalysts – Real-time optimization of route planning, traffic flows, and fleets – PQC-secured over-the-air updates for software-defined vehicles – Quantum sensing for high-precision navigation using magnetic field and inertial sensor technologies as well as miniaturized atomic clocks (ADAS, autonomous driving, robotics, drones) – Quantum battery concepts with ultra-fast charging
 **Materials research, energy & industry**	– Simulation of electronic structures for catalysts and environmentally friendly materials (e.g. new solar cells) – More efficient battery materials, service life and aging simulations – Optimization of power grids and power flows – Production planning, yield optimization, and AI-driven anomaly detection
 **Medicine & chemistry**	– Quantum computers for rapid molecule screening and simulation for medicine (new vaccines, new medications, cancer research) – Quantum sensing in highly sensitive magnetic field measurements (nerves and muscles) for non-invasive brain-computer interfaces, for example for thought-based cybernetic control of prostheses, computers, or even smartphones – Lab-on-a-chip sensor technologies for analytics, diagnostics, and personalized medicine
 **Security & IoT**	– Quantum communication: End-to-end encryption for long-term digital systems – Post-quantum cryptography (PQC) for smart homes, industrial IoT, identity documents and cards, emails, etc. – Protection against cyberattacks – PQC-capable security architectures combined with secure microcontrollers so that systems are ready for the quantum age in the long term
 **Finance, logistics, production & robotics**	– Portfolio optimization and risk modeling – Route, warehouse, and production planning under real-time conditions – Energy management in complex systems – Authentication, navigation, and real-time interaction of robots
 **Artificial intelligence**	– Processing extremely large and high-dimensional data sets – Energy-efficient acceleration of training and calculation processes – Reduced energy consumption and lower CO_2 emissions with faster quantum-driven AI architectures[3]

Quantum technology as a business

In 2025 quantum technologies developed increasingly from a pure field of research into an actual business case, with more than 7,400 organizations and companies already active in this area.[4] At the same time there has been clear acceleration in market consolidation: Rising numbers of mergers and acquisitions in 2025 are a clear sign of maturity, focus, and readiness to invest. The market is beginning to orient itself towards commercially scalable products: Quantum technologies are becoming factors in management and portfolio decision-making and are no longer purely research concerns. The crucial lever lies in industrialization: Success in realizing sustainable value creation is reserved for those who master the transition from demonstrators to robust, scalable solutions. This necessitates early investments in specialized semiconductor technologies, industrial manufacturing, and resilient supply chains.

Infineon is taking this early action and is positioning itself as the pacesetter for the industrialization of quantum technologies in a strategically very important future market. Nevertheless, success will be decided along the entire value chain: In addition to innovative semiconductor companies, this calls for strong system integrators who transform technological breakthroughs into marketable products. This is even more so the case in Europe.

Infineon's contribution to quantum technologies

Infineon assumes an active and leading role in the quantum ecosystem:
- As a partner in development and technology and as a hardware vendor for quantum computing and quantum sensing
- As a security vendor in the field of post-quantum cryptography
- As a user of quantum algorithms in addressing highly complex logistics, production, and optimization projects in the semiconductor industry
- As a trustworthy partner in the quantum ecosystem, through the active integration of research institutes, start-ups, system players, and standards organizations

This combination of development, manufacturing, application, and security expertise distinguishes Infineon from research-driven players.

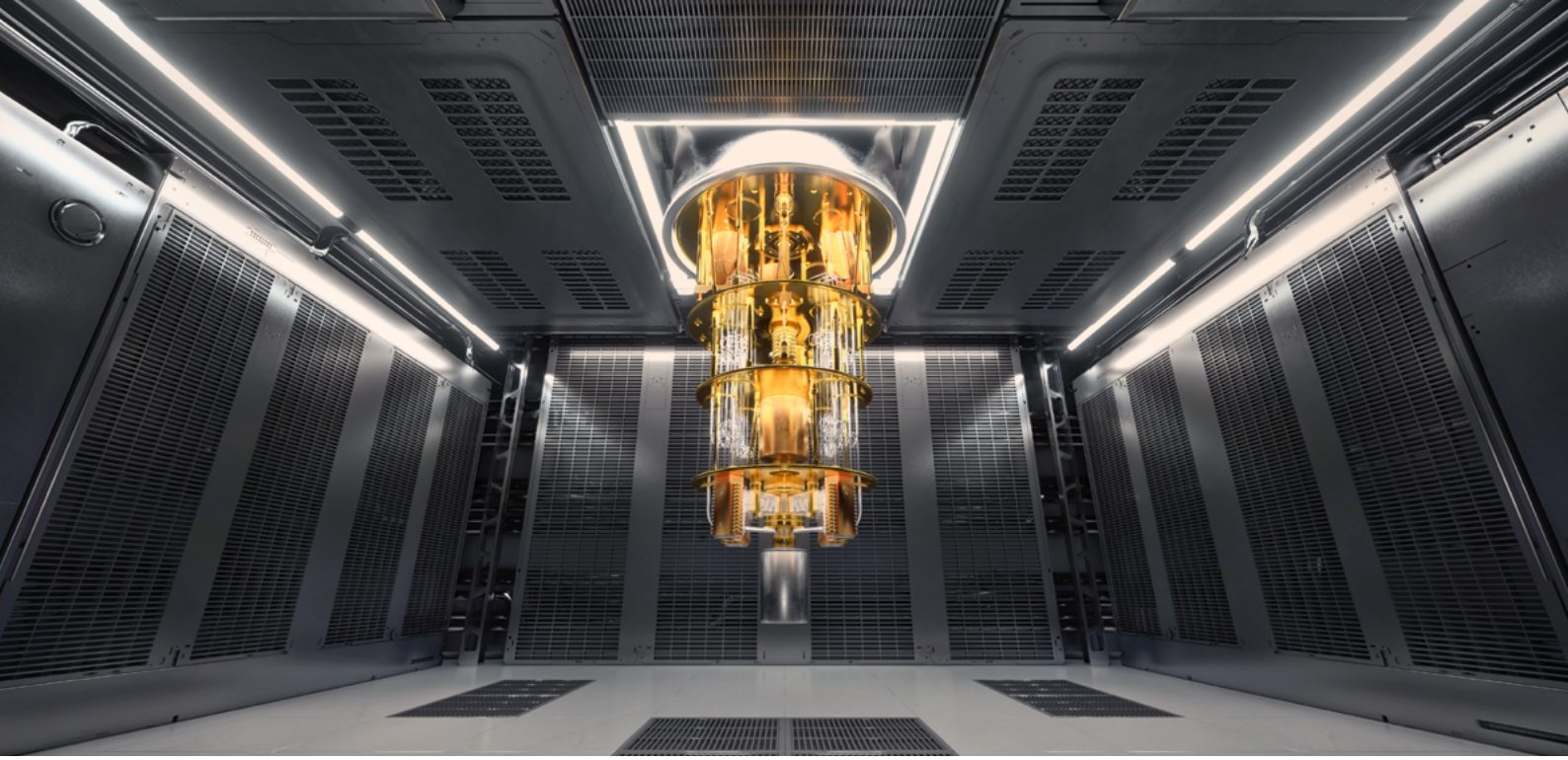
Infineon offers a wide variety of quantum computer technology platforms to advance the development and manufacture of quantum processors, quantum components, and quantum control systems: quantum processing units (QPUs), control and readout electronics, quantum-limited amplifiers (QLAs), RF signal generators, and cryogenic electronics (Cryo-CMOS).

In quantum sensing Infineon is researching and developing high-precision quantum modules based on silicon carbide (SiC) with integrated photonics (system-on-chip). As a semiconductor company, Infineon fulfills a decisive prerequisite for wide-scale industrial use: The capability to realize high-volume production with solutions that are simultaneously miniaturized, energy-efficient, and cost-effective and which can be operated at room temperature – thus making it possible to transition from today's applications in the laboratory and in niche fields to the mass market.

Furthermore, Infineon offers security systems for encryption using post-quantum cryptography. Infineon is among the first companies worldwide to integrate the corresponding technologies in highly certified products (Common Criteria EAL 6+). More detailed information can be found in the chapter "Quantum technologies at Infineon in detail."

Driving decarbonization and digitalization. Together.

As a worldwide leading provider of semiconductor solutions for power systems and IoT, Infineon facilitates leading-edge solutions for green and efficient energy, clean and safe mobility, and an intelligent and secure IoT. Quantum technologies are the next major, groundbreaking key technology, the way artificial intelligence is today. These technologies address matters of energy efficiency and resource efficiency as well as digital security – topics which Infineon decisively pursues and which thus make a central contribution to realizing our vision and mission. This also means that quantum technologies can make an additional long-term contribution to decarbonization and digitalization and can enhance the Infineon vision "Driving decarbonization and digitalization. Together."



Political and regulatory aspects

Quantum technologies are evolving into a key geostrategic technology, impacting economic growth, industrial competitive strength, power balances in national security, and the technological sovereignty of entire economic regions. The global competition for the leadership role has long been in full swing – and is being decided on an increasingly political, regulatory, and industrial-policy basis.

Governments, companies, and start-ups are making enormous investments. Government-subsidized investments in particular are accelerating research, pilot projects, and initial industrial applications. And the competition is no longer academic in nature, it has become a geopolitical contest whose outcome will be decided by industrial realization.

Europe is off to a strong start: Excellent fundamental research, internationally leading universities, high-performance research institutes, and initial industrial use cases – for example in chemistry, optimization, and engineering. This lead is however not self-supporting. Without an ambitious policy framework, Europe is indeed at risk of falling behind in scaling and market penetration in spite of its technical excellence.

Now the targeted and coordinated transition from research to industrial value creation is a decisive factor. Policymakers and the public sector have to guarantee reliable basic regulatory conditions, long-term investment security, and technological sovereignty. Thus an ambitious implementation of the announced EU Quantum Act can make a significant contribution to driving quantum technologies in Europe forward. At the same time, industry is responsible for making rigorous progress in terms of commercialization, scaling, market access, and a focus on application.

In order to transform research excellence into industrial value creation, Europe needs clear technological ambitions, resilient value chains, strong system integrators, and competitive investment incentives.[5]

The USA dominates system integration, software and algorithms, venture financing, and market access; China is systematically expanding its research power and intellectual property – under state control and oriented to the long-term timeframe. Following in the footsteps of semiconductors and AI, quantum technologies are becoming a disruptive key technology.

Europe has a unique opportunity to take the lead in quantum computers, thanks to industrial pioneers like Infineon, among others, who are helping shape the scaling of these technologies. Around the world, quantum technologies are being orchestrated strategically in order to avoid technological dependencies and ensure sovereignty. In spite of this competition, it is still important to emphasize global synergies, for example in the form of targeted industrial collaboration.

Quantum technologies at Infineon in detail

Quantum computing

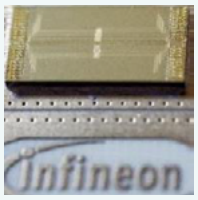
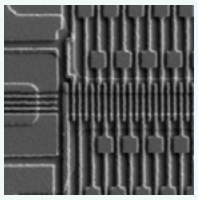
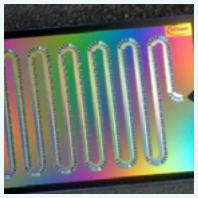
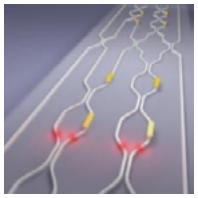
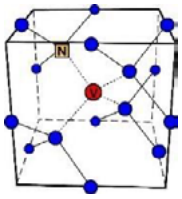
Qubits are the basic building blocks of quantum computers. In contrast to classical bits, which can only assume either the value 0 or the value 1, thanks to superposition a qubit can have the values 0 and 1 simultaneously. In addition, qubits can be coupled with one another, a phenomenon referred to as entanglement. This makes it possible to conduct a large number of computational steps in parallel instead of sequentially.

This means quantum computers are particularly powerful and fast for particular applications. Quantum computers will not replace classical computers, they will supplement them. Hybrid systems can combine the respective strengths of these two types of computer. In addition, the combination of quantum technologies with artificial intelligence (referred to as “quantum AI”) unleashes their full potential: The two approaches mutually reinforce one another and generate new possibilities for complex applications. Quantum computers boost the performance capabilities of increasingly complex AI models, while today AI already supports the development and calibration of quantum processors. Together both technologies create a mutually reinforcing potential for digital value creation.

Information is stored in qubits and processed in specifically controlled operations known as quantum gates. The combination of superposition and entanglement results in exponential growth in computing power. This makes it possible to solve highly complex problems such as simulations in chemistry much faster. There are various different technical approaches to the realization of qubits, distinguished by physical principles, stability, and scalability.

Graphic 4 Technologies for realizing qubits and Infineon’s focus

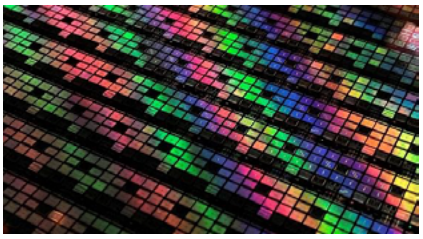
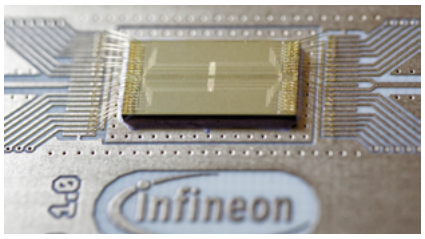
Addressed by Infineon

Leading approaches	Emerging approaches
 **Trapped ions** + High two-qubit gate fidelity	 **Silicon quantum dots** + High scaling potential
 **Superconducting circuits** + Fast two-qubit gates	 **Photonic qubits** + Promising measurement-based approach
 **Neutral atoms** + Favorable scaling tradeoffs	 **SiC / NV* color centers** + Room temperature operation *NV: Nitrogen vacancy in diamond

Infineon has chosen a multimodal approach with three technological platforms

- **Ion traps** catch charged atoms in electromagnetic potentials; laser or microwave pulses alter the energy states and in doing so execute gate functions, a technological approach which is very far advanced at Infineon. Infineon is already producing ion trap chips at industrial quality. The objective is a near-series production process for quantum processors which work with thousands of qubits and which integrate the necessary optics and Cryo-CMOS control. Infineon already has lead customers in this field and is integrated in dedicated roadmaps
- **Superconducting qubits** utilize the fact that currents can flow without resistance at very low temperatures. Tunnel barriers between superconducting components form the basis for qubits and efficient low-temperature amplifiers. Infineon uses its experience in manufacturing precise tunnel barriers to improve these superconducting circuits
- **Silicon-based electron-spin qubits** work with the spin of electrons at very low temperatures. Infineon utilizes its manufacturing and packaging expertise to reliably localize and control individual electron spins in quantum dots. Here the objective is scaling to standardized silicon production processes including control electronics

Graphic 5 Infineon quantum platforms

Silicon quantum dots	Superconducting circuits	Trapped ions
		
CMOS-compatible process enables scalable, miniaturized quantum processing units	Superconducting technology is ideally suited to build quantum devices with high process control	Ion trap quantum processor, manufacturable at industrial scale

Infineon is working on core quantum components and control systems for all three platforms:
Quantum processing units (QPUs), control and readout electronics, quantum-limited amplifiers (QLAs), RF signal generators, and cryogenic electronics (Cryo-CMOS).

Infineon has the most modern quantum laboratories, platforms, and production expertise as well as a highly qualified team of experts. These activities are distributed across several sites: Ion trap platform and front-end manufacturing (Villach), superconducting qubits (Munich and Regensburg), and silicon spin qubits (Dresden).

Challenges and realization roadmap for quantum computing

Progress is essentially determined by which technology platform is the first to achieve a balance between qubit count, error correction, integration densities, and industrial reproducibility.

The central challenges are:

- **Scaling and error tolerance:** Current systems work with a few hundred physical qubits. The transition to millions of qubits requires highly integrated chips, precise manufacturing, and innovative packaging, cooling, and optical concepts
- **System integration:** Powerful quantum computers take shape in concert with quantum processors (QPUs), cryoelectronics, control (lasers/microwaves), integrated photonics, and software. Here the decisive factor is the industrial reliability and scalability of control and measurement systems

Quantum computing is part of a global technology and innovation race between companies, research institutions, and economic regions. Competitive advantages arise with the ability to bring powerful and reliable quantum computers to industrial maturity.

Here the key is the hardware, the scalable and controllable use of quantum effects, increasing the number of qubits and the improvement of qubit reliability. The first economically viable applications will become possible as soon as a sufficient number of error-corrected logical qubits is available.

Graphic 6 Competitors in the field of quantum computing

Source: Olivier Ezratty, arXiv: 2305.09518 (adapted)



Explanation: The graphic illustrates various companies' progress towards broadly applicable quantum computers. Systems with ion traps are characterized by reliability at levels of over 99.995 percent. Here Infineon already has partnerships with leading system integrators.

Hybrid interaction

Conventional (super) computers will continue to be justifiable in the quantum computer era as well. Quantum computers and bit computers will work together in hybrid systems, combining the best of both worlds.

Hybrid quantum computing unites quantum and classical computers to form high-performance, immediately applicable architecture for highly complex optimization and simulation tasks. While classical supercomputers parse these complex problems into subproblems, quantum computers take on the particularly compute-intensive quantum-mechanical calculations. The results are then combined once again. This hybrid approach is considered to be particularly promising in chemistry, biology, and materials science and also in logistics. Working together with partners, Infineon uses this approach in a focused manner to optimize complex manufacturing processes in real time, in particular in production planning, material development, and supply chain control. As an early user, Infineon guarantees itself a clear competitive edge in the data-driven, highly automated production facilities of the future.

Quantum technologies unleash their true power in combination with other future-oriented technologies – for example with artificial intelligence, robotics, autonomous driving, and cybersecurity. The combination of AI and quantum computing, "quantum AI," represents major potential. The quantum computer is predestined to improve computing power for increasingly complex AI models – in particular quantum machine learning (QML). Conversely, today AI can already help with the calibration of quantum processors. Together these two mutually reinforcing technologies could even herald a new era of digital value creation.

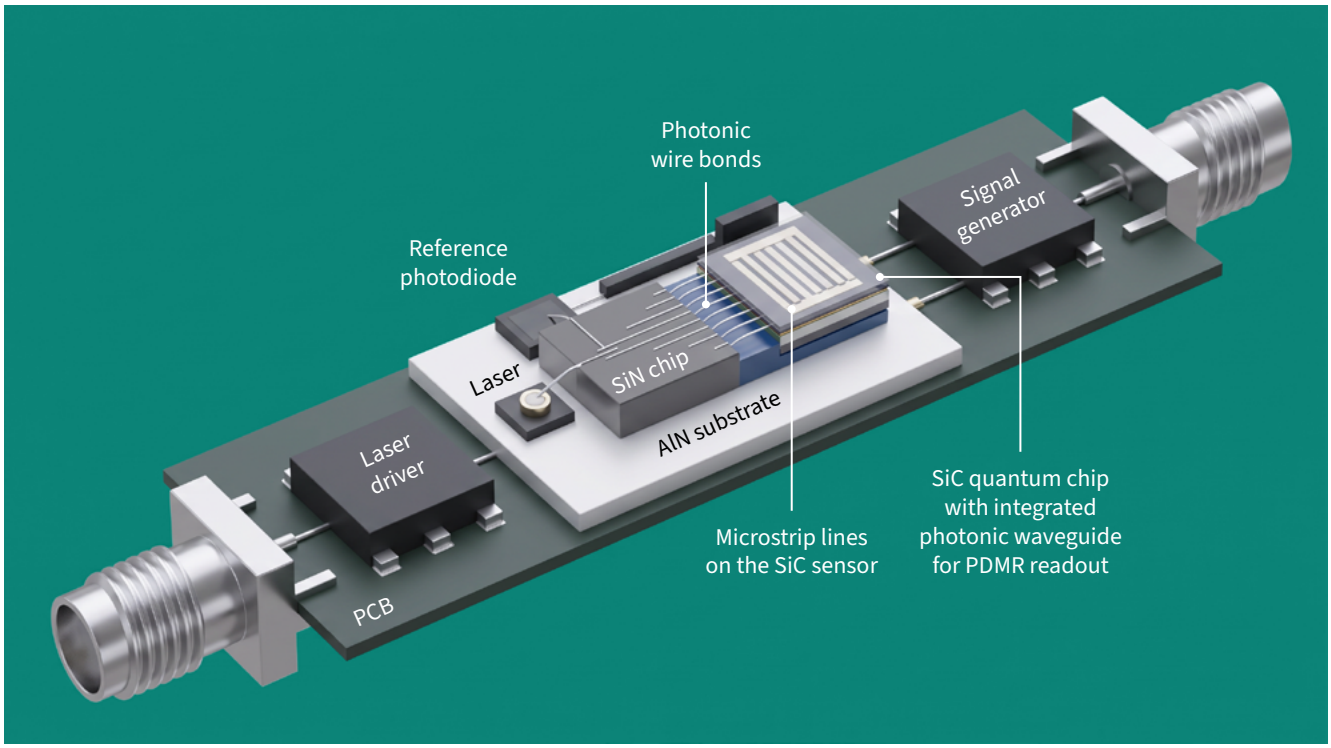
Quantum sensing

Building on its expertise in mixed-signal, radio-frequency, and power electronics, Infineon is specifically investigating the use of high-precision quantum sensors and their integration in existing and new applications. The focus is on robust system solutions, including appropriate calibration processes and mastery of noise. At the same time, the integration of energy-efficient CMOS-based control and readout electronics is also being evaluated.

Quantum sensing enables significantly higher levels of measurement precision and sensitivity compared to today's classical sensors. Based on its long history of technology expertise and the high ease of integration, Infineon is focusing on the silicon carbide (SiC) material system in particular. SiC is not only well suited to quantum sensing, but also opens up new application perspectives in quantum communication and high-precision time measurement. For example, quantum sensors can be used to measure extremely small magnetic fields in the pT/√Hz range and in the area of rotational measurement (gyroscopic effect). Infineon is already developing a demonstrator capable of extremely high-precision detection of magnetic fields. This opens up new possibilities, for example for non-invasive human-machine communication that does not require implanted electrodes or chips.

Infineon is applying its expertise in system-on-chip solutions, miniaturization, and photonic integration in package (PIiP) to transfer complex quantum sensing systems into compact form factors. Here the central components (laser, SiC sensor, optical waveguides, and radio-frequency coils) are combined in a compact system and thus reduced substantially in size. The result: The know-how of the microchip industry can reduce the dimensions of a laboratory system the size of a refrigerator so that it fits entirely into a tablespoon.

Graphic 7 Infineon quantum sensor development



Post-quantum cryptography

High-performance quantum computers also entail the risk of existing encryption procedures being broken. This impacts applications like government ID cards, health care IDs, online banking, and email communication in particular. Sensitive information can be exposed, financial systems can be compromised, and the digital backbone of entire industries can be undermined.

One tangible risk is already manifesting today: Attackers can collect data now in order to decrypt it in the future with high-powered quantum computers (“Harvest now, decrypt later”). This means companies and governments have to transition to post-quantum cryptography (PQC) today in order to prepare for the attacks of the future.
Companies operating critical infrastructures in the EU are to switch to post-quantum cryptography by the end of 2030.[6] Other countries are considering similar regulations or are already in the process of implementing them.[7]

As a leading provider of secure embedded systems, Infineon is driving progress in the resolution of this challenge. Infineon is working on the development and standardization of post-quantum cryptography and is collaborating with leading security and standardization institutions. One central approach is crypto agility: Today this hardware already supports established encryption procedures and will also be able to implement new algorithms in the future, for example those standardized by the National Institute of Standards and Technology (NIST).

Infineon is among the first companies worldwide to offer certified security solutions with PQC support. Today these solutions are already at work in applications like eSIMs, 5G SIMs, and national identity documents. In addition, Infineon already offers a PQC-protected firmware update mechanism for Trusted Platform Modules.

Graphic 8 Infineon post-quantum cryptography solutions (as of June 2026)



OPTIGA™ TPM SLB 9673 FW26
OPTIGA™ TPM SLB 9672 FW15
OPTIGA™ TPM SLB 9672 FW16



PSOC™ Control Performance Line Family



PSOC™ Edge



TEGRION™ Product Family



SECORA™ Pay



AURIX™ TC4x



TRAVEO™ T2G



Partners and quantum ecosystem with Infineon

Infineon maintains a tight-knit network with leading quantum companies, system integrators, start-ups, research institutions, universities, and users to develop and scale quantum computing, quantum sensing, and post-quantum cryptography, oriented towards industrial applications. Infineon is currently actively represented in the following central international and European initiatives:

- **QUTAC (Quantum Technology and Application Consortium):** Consortium of leading German industrial corporations whose objective is industrializing quantum computing from the point of view of the user. https://www.qutac.de
- **QuIC (European Quantum Industry Consortium):** European network for the development of a comprehensive industry ecosystem for quantum computing, quantum sensing, and quantum communication. https://www.euroquic.org
- **MQV Munich Quantum Valley:** Joint initiative of science and industry for the establishment of a center for quantum technology, including infrastructure and research as well as training and continuing education. Members include for example the Bavarian Academy of Sciences and Humanities, Fraunhofer, Max Planck Society, Ludwig-Maximilians-Universität Munich, and Technical University of Munich. https://www.munich-quantum-valley.de
- **QVLS Quantum Valley Lower Saxony:** Broad ecosystem uniting research institutions, industry, and industry associations, including Leibniz University Hannover, Technical University of Braunschweig, National Metrology Institute of Germany (PTB), Max Planck Institute for Gravitational Physics Albert Einstein Institute, DLR Institute for Satellite Geodesy and Inertial Sensing, Sartorius (pharmaceuticals process and technology specialist), NiedersachsenMetall (employers' association), and QubeDot (GaN start-up). https://qvls.de
- **QSens Quantum Sensing Future Cluster:** Development of scalable SiC-based quantum sensors up to and including miniaturized modules, together with partners from science and industry (for example, University of Stuttgart and IMS Chips). https://www.qsens.org/

In addition, Infineon is actively engaged in the development and establishment of international standards and works together closely with relevant institutions such as BSI and NIST. (NIST Cybersecurity Framework)

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