MEDIA BOOK

Kulim 3

Infineon is building the world's largest and most efficient 200-millimeter SiC Power Fab in Kulim, Malaysia. Get a glance behind the scenes and meet the experts.

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Introduction

Climate change is the biggest challenge of our time and the global decarbonization efforts will rapidly increase the demand for power semiconductors. As the world market leader, Infineon is constantly expanding its portfolio with new generations of power semiconductors based not only on silicon, but also silicon carbide (SiC) and gallium nitride (GaN). With higher power density and higher energy efficiency, these chips offer smaller size and lower costs.

To match the growing demand for these chips, Infineon is investing in the world's largest and most efficient 200-millimeter SiC Power Fab. The first part of the fab is ready for production in 2024. This investment underlines Infineon's leadership position for energy efficient power chips in industrial and automotive applications.

This booklet provides facts, figures and insights of Infineon’s experts about the expansion. It gives financial, technological and economical information to understand the context of this ambitious project. It will explain the applications for SiC and GaN and how chips based on these materials contribute to the global decarbonization efforts. It will also contextualize the importance of the project for the Malaysian semiconductor ecosystem.

The short articles and info boxes are supplemented by short video clips with our experts.

The Kulim 3 construction site, early June 2024

Infineon’s plan for Kulim

In the face of climate change, the transition to a sustainable energy supply system is crucial. Infineon is committed to meeting this challenge by investing in technologies that drive energy efficiency. Power semiconductors play a key role in enabling the switch to renewable energy and electrified applications – from electric vehicles to data centers – thus creating a net-zero economy.

In the dynamic world of power electronics, the pursuit of efficiency has led to a new class of power transistors known as wide-bandgap (WBG) semiconductors, based on the materials silicon carbide (SiC) and galium nitride (GaN). These transistors are revolutionizing power electronics and various applications involved in the green and digital transformation.

In Kulim, Malaysia, Infineon significantly expands the capacity dedicated to wide-bandgap semiconductors. The site will host the world’s largest and most efficient fab to produce silicon carbide (SiC) on 200-millimeter wafers and include also GaN epitaxy. The investment will create 900 high-value jobs at Infineon already in the first phase and overall 4,000 Jobs at the end of the project. (Please check the press releases from February 2022 and August 2023 for more information.)

The project is split into two parts. Early summer 2024, the first part of the Fab is ready for production. The second phase, with an investment of up to five billion euros, will create the world’s largest and most efficient 200-millimeter SiC power fab. The investment will help customers to bring energy efficient solutions to the market in industrial and automotive applications – and ultimately strengthen Infineon’s global leadership role in power semiconductors.

Key facts

- Infineon builds the world’s most efficient and most sustainable 200-millimeter frontend fab for SiC power semiconductors.
- Wide-bandgap semiconductors will increase energy efficiency in industrial and automotive applications, supporting the green and digital transformation.
- Opening of the first part in August 2024

2006
Infineon opens first silicon fab in Kulim

2016
Fab2 is opened

2022
February: announcement of € 2bn Wide Band Gap fab

2022
July: Foundation Stone Ceremony for Kulim 3

2022
August: additional announcement of € 5bn investment

2024
Spring: first part of Fab 3 is ready for equipment

2024
August: Opening of first part of Fab3

"With this most efficient fab, we want to achieve economies of scale for silicon carbide. Here in Kulim, we have already achieved economies of scale for silicon production. And we will continue our journey to establish with silicon carbide the most competitive power fab as we have already the existing economies of scale."

Ng Kok Tiong
Infineon Kulim,
Senior Vice President and Managing Director;
KLM3 Project Owner

"As we are situated in Southeast Asia, we have of course the factor cost advantage, especially regarding personnel cost. On top of that, the Malaysian government has also been providing us support for our growth since our start back in 2005."

Kam Ai Mei
Infineon Kulim, Vice President & CFO

"From the beginning, our task was to fully support the ramp-up of Kulim."

Thomas Reisinger
Infineon Technologies Austria,
Board Member Operations

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The big picture in Operations

As the market leader in power semiconductors, Infineon is leading the way across the whole range of power semiconductors – for silicon chips as well as for technologies based on SiC and GaN. This leadership position is based on excellence in manufacturing, which enables a scalable and resilient business.

As the leading power semiconductor supplier with highly resilient, stable manufacturing and delivery capacity around the globe, Infineon has unique in-house capability in both frontend and backend. Building on a high-volume production track record, Infineon combines operational excellence with reliable multi-sourcing agreements for raw materials, including SiC material.

Infineon's manufacturing strategy is based on clear principles: We focus on expanding our in-house manufacturing in those areas in which added value for our customers and differentiation for Infineon is created. This is the case, for example, for power semiconductors and sensors. However, in the case of highly integrated digital products such as microcontrollers and connectivity and security components, we prefer to work together with contract manufacturers.

The current investment in our own manufacturing capacity in Kulim will strengthen the leading position of Infineon in SiC and GaN technology – together with the expansion of wide-bandgap-capacity in Villach, Austria. Infineon sites in Kulim and Villach will gain advantages from scaling effects and from Infineon's leading know-how such as the Cold Split technology, which leads to the most efficient usage of SiC material.

How Infineon is positioned in silicon carbide (SiC) technologies

Certain strengths differentiate Infineon from its competitors:

- excellence and reliability with SiC raw material based on a strong network of SiC material suppliers, the Cold Split technology that enables a particularly efficient use of the raw material and the ongoing conversion to 200mm manufacturing.
- a superior trench architecture that allows 30% more chips per wafer and unmatched reliability with zero field returns
- the most comprehensive product and packaging portfolio
- a deep system understanding

The company has all the key factors at its disposal for sustainable success with SiC solutions and already serves 3,600 customers worldwide with SiC.

"Infineon is the biggest player in silicon power semiconductors. And we also want to lead in silicon carbide and gallium nitride."

"Silicon carbide will be technology to grow in the next decade. Many applications in automotive, in renewable energy, in data centers will be based on the technologies of silicon carbide and gallium nitride."

Rutger Wijburg
Chief Operations Officer

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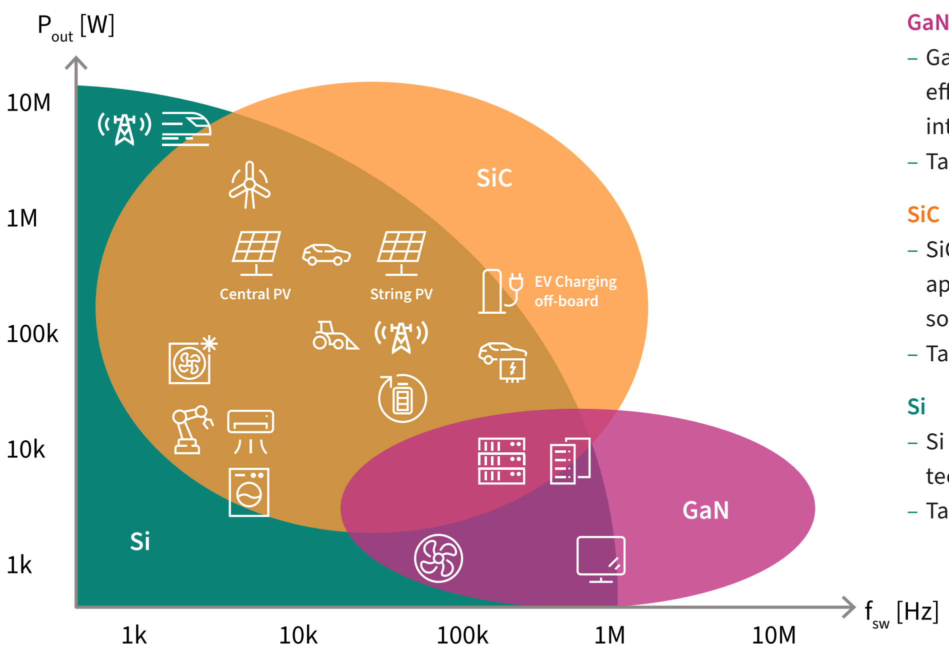
Wide-Bandgap

Technological basics, the market, and applications

Silicon has played a leading role in power electronics for over 50 years. The maturity of silicon semiconductor technology has meant that silicon-based power components can be manufactured cost-efficiently in large quantities and with a high degree of reliability. In power electronics, however, the material is reaching its limits due to increasing specific demands on power circuits.

Compound materials such as silicon carbide (SiC) and gallium nitride (GaN) are superior to silicon (Si) in terms of various physical parameters. Due to its high thermal conductivity, SiC is used where high power densities are required, while GaN is predestined for high-frequency applications.

SiC semiconductors are a game-changer in high-power applications due to their ability to sustain high voltages and temperatures while offering reduced switching losses. GaN shines in high-frequency applications, such as radar systems and microwave, attributed to its excellent electron mobility. The advantages of wide-bandgap materials in electronic components cannot be overstated. SiC and GaN transistors offer significantly lower on-resistance and faster switching capabilities than their silicon counterparts. Less energy is wasted as heat and more energy is available for the device's intended purpose. SiC and GaN transistors will significantly contribute to the green and digital transformation.



GaN
- GaN enables new horizons in efficiency, power density, system integration and bi-directionality
- Targeting 40 V – 650 V

SiC
- SiC complements Si in many applications and enables new solutions
- Targeting 650 V – 3.3 kV

Si
- Si remains the mainstream technology
- Targeting 25 V – 6.5 kV

Applications for which wide-bandgap is predestined

"The demand for gallium nitride devices is increasing extremely fast, with a high double-digit CAGR. To fulfill this demand, it is important that we as the market leader scale the manufacturing capabilities and the manufacturing capacity."

Johannes Schoiswohl
Senior Vice President Business Line GaN

"The competitive environment in silicon carbide is steadily growing. Many more players are stepping into this very interesting technology because they recognize the benefit and the importance of silicon carbide. Therefore, we need to take measures to keep our position as a leader in power semiconductors. To this end, the 200-millimeter high-volume fab in Kulim is one of the most important ingredients: here we will see economies of scale outperforming everything we know so far from other regions in the world."

Peter Friedrichs
Fellow SiC Innovation and Industrialization

Technical background

A bandgap is a fundamental property of materials that dictates their electrical conductivity. In semiconductors, it is the energy difference between the valence band (occupied by electrons) and the conduction band (where electrons are free to move and thus conduct electricity). Traditional semiconductors, like silicon, have a smaller bandgap, which enables them to conduct electricity with moderate ease but also limits their performance in high-temperature and high-voltage environments. Wide-bandgap materials, however, have a larger bandgap. This quality allows semiconductors made from these materials to operate at much higher temperatures, voltages, and frequencies. They offer remarkable efficiency and power density, which translates to smaller, lighter, and more efficient devices. Furthermore, WBG devices demonstrate superior thermal performance, which means they can dissipate heat more effectively, leading to enhanced reliability and longer operational life spans. The most common WBG materials garnering attention are silicon carbide (SiC) and gallium nitride (GaN).

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The construction works

"Building semiconductor fabs is the Champions League in industrial construction," says Andreas Wittmann, Vice President Front End Facility Management at Infineon Technologies AG. This describes the challenges the team were facing in completing the first phase of the Kulim fab in time – and driving the world's largest and most efficient 200-millimeter SiC Power Fab.

The project was started during the Covid pandemic, followed a highly ambitious schedule and it brings completely new technologies out of the laboratory and into mass production. An important key to the success was the know-how and dedication of Infineon's local experts. They directly commissioned 15 different companies and managed the workflow of up to 5,000 workers that have been simultaneously on site.

They construction followed a strict schedule, but it was highly flexible. Already 13 months after the start of the construction, Infineon has managed to push in the first tool into a cleanroom. This major achievement was a result of the modular design of the cleanroom. To speed the project up, Infineon brought in equipment step by step, room by room, while the construction of the fab was still under way.

Not only in Kulim, but also in Villach, Austria, engineers worked on the successful start of production. They began early to qualify technologies and processes for wide-bandgap semiconductors with the goal to scale it to mass production in Kulim. In the meantime, Kulim workforce obtained important know-how during on-the-job-trainings in the scenic Austrian town Villach – allowing for a smooth and efficient start of production back home in Malaysia.

Facts & figures

Parameters	Numbers
People hours until 1 April 2024	12.2 million
Number of precast concrete elements	8,192 (combined length ~350 km)
Combined length of electrical cable	~600 km
Combined length of pipe work	~150 km
Combined length of piles	~330 km
Largest beam weight	26 t
Number of piles	9,900
Steel reinforcement bars	32,500 t
Accumulated time spent for on-the-job training	58,792 people hours
Total water storage (including rainwater and transfer)	~18,500 m^3 (18.5 m liters; ~the size of 8 Olympic sizeswimming pools)
Transfer water tank	450 m^3 (450,000 liters)
Rainwater harvesting tank	3,000 m^3
Water storage tank	15,000 m^3
Development area for phase 1 and phase 2	35 acres

"Manufacturing of chips requires precision at atomic level, which means that the facility housing a range of semiconductor technologies and equipment also has to be made very precise and accurate, to facilitate chip manufacturing at exactly the atomic precision level."

Dr. Raj Kumar
KLM3.1 Project Manager & IFKM
Senior Vice President, Technology and R&D

"For this particular project, our responsibility was a focus on the automation of the factory. While in a regular factory we typically have a lot of operators for the machines, this environment is completely automated at Infineon: the operator just has to load something on the machine, and the computer system takes care of everything and ensures that everything is processed until the end. So, when we build a new fab, we have to assess what specific system to bring in for any particular area."

Andreas Wittmann
Vice President Front End Facility Management

"What I'm really proud of in this project, is, that we have managed to push in the first tool into the finished cleanroom within 13 months from construction start – one of the quickest construction periods I have heard of."
"We have achieved this by designing the cleanroom in a modular way, which means that we can handover certain parts of the cleanroom earlier while we are still constructing other areas at the same time."

Dirk Hewer
Senior Project Director,
Facility Management Department
KLM3 Project Owner

"Building semiconductor fabs is the Champions League in industrial construction."

Andreas Wittmann
Vice President Front End
Facility Management

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Sustainability at Kulim 3

Infineon's follows the ambition, not only to be a technological leader, but also a pioneer in sustainability. For this reason, the Kulim 3 fab will implement innovative solutions aiming at increasing resource efficiency and reducing the environmental footprint as much as possible.

Kulim 3 is built to the best industry standards for energy efficiency. For instance, the measures include state-of-the-art PFC abatement systems, pressure independent balancing control valves to optimize efficiency of the air conditioning, solar panels on the roof, buffer zones for tree planting and grass turfing at the green buffer zones. The consumption of potable water is reduced with rainwater harvesting, water recycling and the use of water-reducing sanitaryware. In addition, the site will source green energy in the future.

The investments in sustainable technology complement the positive climate effect of Infineon products that contributes to the global energy transition and thus to a net-zero society. Infineon semiconductors are used in solar and wind power plants, electric cars and increase energy efficiency in numerous applications, including AI data centers. Over their lifetime, the company's chips overall save 34 times the amount of CO_2 emitted during their production.

Rainwater Harvesting Tank…
… is the first of its kind at Infineon. It enables Infineon to harvest rainwater to be used for the cooling tower, hence saving of 300,000 cubic meters of water annually. Malaysia is a tropical country that enjoys warm temperatures throughout the year, ranging from 21 degrees to 33 degrees Celsius. Cooling is essential.

Hydrogen…
… is one of the main bulk gases used in the WBG EPI deposition process. In Kulim 3, Infineon uses hydrogen generated by an electrolyzer out of water rather than generated by steam reformer out of fossil methane.

Refrigerants
The use of zero ozone depletion potential (ODP) and ultra-low global warming potential (GWP) R-1234ze HFO refrigerant has been implemented for all the centrifugal chillers in KLM3 project.

General measures for sustainability

"Kulim 3 is designed to meet a range of sustainability standards. One example is rain harvestingto collect all the rain and release it back to our productions."

Zubir Othman
Director Environmental Health and Safety

"For Infineon, sustainable manufacturing means avoiding emissions. And the key lever here is PFC abatements. We have installed this technology across all our frontend sites already. And with this, we are able to save two thirds of our "scope one" emissions. And of course, Kulim three will be equipped with this latest technology from day one. The second big lever is green energy. And we are very proud that we will be able to switch to 100 per cent renewable energy as of 2025. We have already moved in Melaka and Kulim to renewable energy in 2023."

Elke Reichart
Chief Digital and Sustainability Officer

"The Kulim 3 fab we are building, is constructed according to the highest sustainability standards by design. We target to be green building certified; we have the potential of a heat recovery of 20 percent of the overall fabrication and plan to recycle more than 50 percent of our fresh water."

Dirk Hewer
Senior Project Director, Facility Management Department

"In terms of sustainability, we focused on water, but incorporated many more measures. All our electrical drives are variable speed drives. We have implemented heat recovery systems to reduce the energy losses of our factory to the minimum. The latest technologies that we provide for the market we are implementing on our own and we are harvesting the benefits of these energy efficiency measures."

Andreas Wittmann
Vice President Front End Facility Management

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“One Virtual Fab”

for wide-bandgap technologies

The new fab in Kulim, Malaysia, will be deeply connected with the Infineon site in Villach, Austria. “Kulim and Villach act like siblings,” says Thomas Reisinger, Member of the Board of Infineon Austria AG. The sites Kulim and Villach already share a history of nearly 20 years cooperating together. In the One Wide-Bandgap project, Infineon makes full use of this long-lasting relationship.

Infineon will implement existing technologies and processes for SiC and GaN production from Villach to Kulim in order to be able to serve the future market demands. The project setup is adopted from the successful running “One Virtual Fab” project, that harmonizes the high-volume 300-mm Silicon production in Villach and Dresden.

This cooperation aims to generate synergies and increase the speed and efficiency of the ramp-up: In Villach tested and certified technologies, machines and processes are scaled in the mass production in Kulim. Workforce from Kulim is trained on-the-job in Villach in order to run operations in Kulim. This close cooperation between Austria and Malaysia accelerates the ramp-up of the WBG production line in Malaysia, guarantees that established and reliable setups are introduced right from the start and ultimately contributes to global supply chain stability.

Key facts on “One virtual fab” for wide-bandgap technologies

- Villach is Infineon’s competence center for wide-bandgap: the leading technologies SiC and GaN have been developed at the Austrian site.
- When the technologies go into large-scale production, Infineon brings these technologies to Kulim, where is enough space to grow. This ensures a reliable high-volume production, supply chain stability as well as quality and efficiency.
- The Villach site is the innovation base and global competence center for wide-bandgap technology. 150-mm and 200-mm silicon production lines will be converted to SiC and GaN manufacturing by repurposing non-specific silicon equipment.

"The '1WBG' or One Wide-Bandgap concept means that we treat Kulim and Villach as one large virtual fab and ignore the different locations: the systems between Villach and Kulim are completely synchronized. It may be two different locations, one in Kulim here in Malaysia, another one in Villach; Austria. But they are connected via wide area network, forming one large synchronized system."

Lew Peng Moon
Director Factory Integration

"Basically, we copy exactly the setup in Villach and duplicate it in Kulim, making sure that both sides are harmonized at the end of the day. Moving forward, we could be also developing in Kulim. And once we start development in Kulim, we still need to maintain this harmonized '1WBG' setup. And there may be topics that would then be copied from Kulim to Villach."

Danny Tan
Senior Director Unit Process Development

"Kulim and Villach act like siblings and it is nice to see that the younger sibling is growing up. And with this, we enter a new era for Infineon."

Thomas Reisinger
Infineon Technologies Austria, Board Member Operations

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The local tech cluster

Infineon has deep roots in Malaysia, going back to the year 1973 when the backend-site in Melaka was launched

Infineon has deep roots in Malaysia, going back to the year 1973 when the backend-site in Melaka was launched. In 2006, Infineon opened its first front-end site in Kulim. The business grew since then and Infineon currently employs more than 16,000 people in Malaysia. “Infineon and other well-established German corporations’ continued faith in Malaysia is a vote of confidence” said Dato’ Seri Anwar bin Ibrahim, Prime Minister of Malaysia, in a press release in 2023 expressing his appreciation for Infineon’s commitment to creating a significant wide-bandgap hub in the country.

Infineon Kulim is located in Kulim Hi-Tech Park (KHTP), the first high tech park in Malaysia. The industrial zone was officially founded in 1996. Kulim is a growing township in the state of Kedah, the northern region of the Malaysian peninsula.

KHTP combines work and life, industry and people. 34,000 people work there, 47 industrial companies have production site at the Hi-Tech Park. KHTP is focusing high tech manufacturing, advanced technologies and research & development activities. A perfect neighborhood for Infineon and its fabs.

Kulim Hi-Tech Park

- Total Area: 5,551 acres (round about 22.5 square kilometers)
- Six dedicated zones for Industrial, R&D, Residential, Urban, Amenities and Institutional
- Total Workforce: 34,000

"At the Hi-Tech Park, we have a lot of companies; talents find it very attractive to work here, as they have a lot more choices to find opportunities at the companies here."

Ng Kok Tiong
IFKM Senior Vice President and Managing Director; KLM3 Project Owner

"In the Kulim Hi-Tech Park we have more than 30 companies; and I'm proud to say that Infineon Kulim is listed among the top three, in terms of the number of employees that we have."
"One of the advantages of this park, where we are today, is that we are equipped with sufficient infrastructure that is critical for our processes in frontend. Besides, the Hi-Tech Park always provides us sufficient support, not only regarding infrastructure but also in other ways, to ensure that our needs regarding construction or our growth in Kulim is fully fulfilled."

Kam Ai Mei
IFKM Vice President & CFO

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How to acquire workforce

Infineon is regarded as an attractive employer in Malaysia. This is also because the company has established a strong collaboration within the industry and the academic world in Malaysia. These partnerships aim to provide a platform of practical and scientific knowledge sharing, especially in technical aspects of wafer fabrication. Infineon Kulim even extended its strategic collaboration by actively supporting a partnership between universities in Malaysia and Germany.

"Over the years, Infineon has built a reputation as an employer of choice. A lot of people like to work for us; especially the new generation, because people are aware that Infineon, put their best interest in developing employees. Although there is a worldwide race for talent and we also face some challenges, we can fill all open positions in a timely manner thanks to our reputation, our connections to the local universities and our additional efforts."

Dr. Raj Kumar
Senior Vice President, Technology and R&D

"At Infineon Kulim we believe our people are key to our success and growth. With this in mind, we continuously strive to enable our employees with the right competencies so that they can be successful in their roles, deliver outstanding results, and maintain a high engagement levels."

Lena Tan Cheng Imm
Senior HR Director

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Kulim and a strong network of suppliers

A front-end production facility is highly complex and requires a broad range of materials. For all of its front-end production sites, Infineon needs several thousand different materials – most of them are process materials comprising chemicals, gases, photo chemicals, and others.

Most important for Kulim 3 are silicon carbide raw wafers. The market for these wafers is getting more and more commoditized and Infineon has secured contracts with a variety of suppliers to source as many wafers as needed at very competitive pricing and in the best quality. This strong network also allows Infineon to smoothly ramp-up the 200-millimeter production in Kulim.

Fabs are in the center of a bigger landscape of suppliers. The Kulim Hi-Tech Park alone has a wide network of suppliers with know-how in equipment and support. This strong ecosystem ultimately helps all players not only in terms of operations, but also in talent attraction.

"For establishing a robust and reliable supply chain for our fab in Kulim, we need to apply a broad range of measures: we are always going for a multi-country sourcing strategy, meaning that we source our material from different countries as well as from different suppliers. We also enter in strategic partnerships with selected suppliers. Additionally, we regularly screen the market regarding new suppliers and innovation."

Silke Sorger
Senior Vice President Procurement

"We started our gallium nitride journey with six-inch wafers. But very quickly, we moved to eight-inch wafers, meaning: eight-inch silicon base material and growing the GaN epi there."

Johannes Schoiswohl
Senior Vice President Business Line GaN

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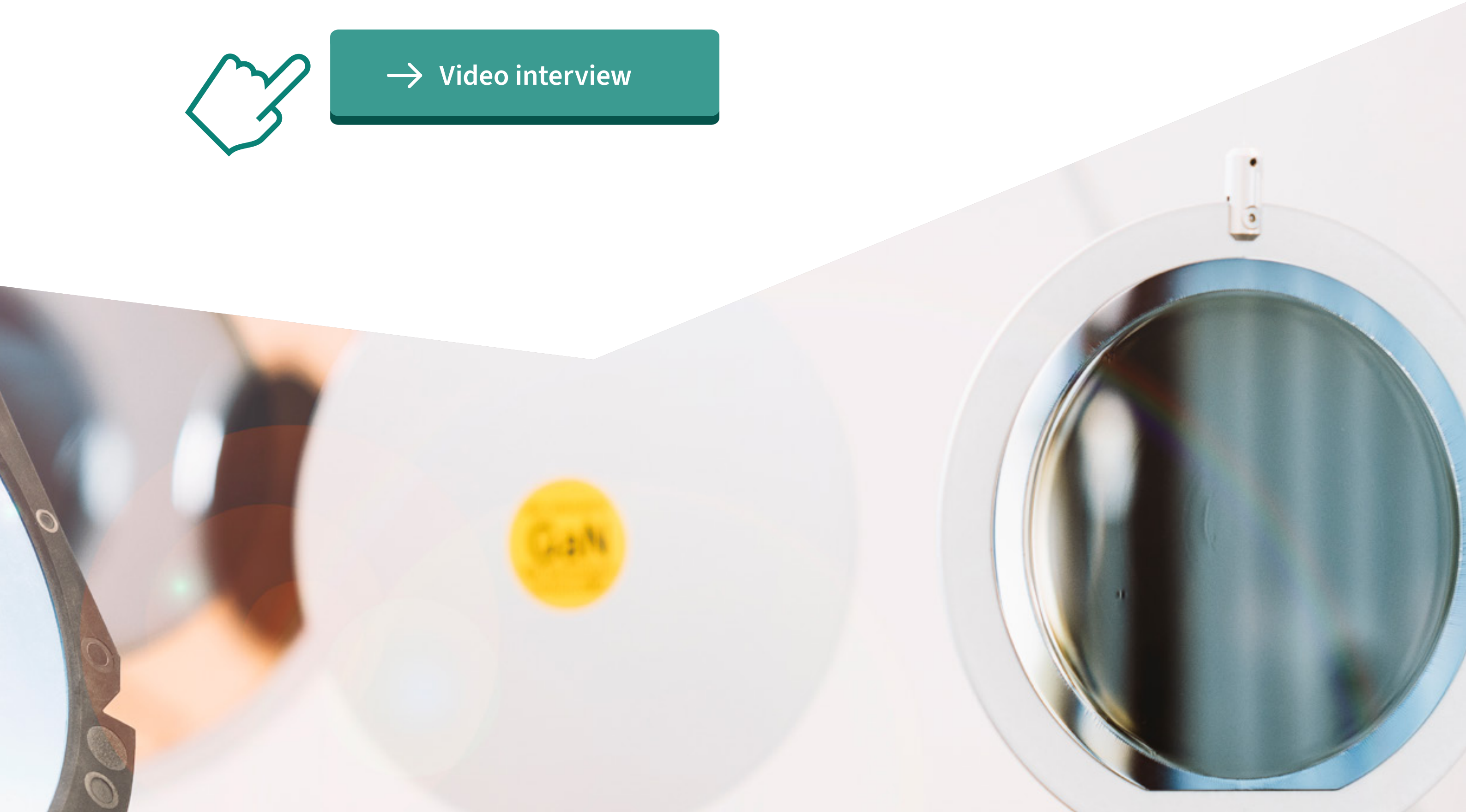


How an "SiC" chip is made

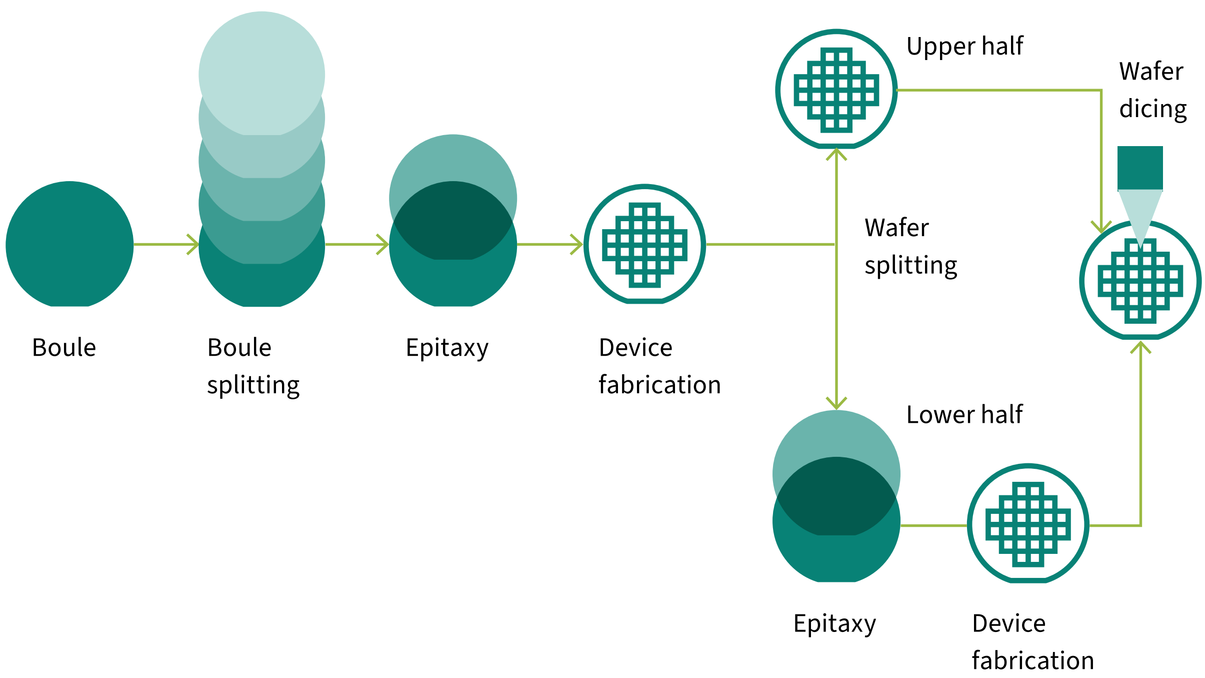
All chips start out with a very simple raw material: sand that primarily is silicon dioxide, $SiO2$. The sand is combined with carbon and heated to an extremely high temperature to remove the oxygen. A number of other steps are required to create an extremely pure monocrystalline silicon ingot, called a boule.

Silicon carbide also uses high purity silicon, but in addition also carbon as precursors to grow crystals. Both materials are initially at very high temperatures synthesized into a powder, which will be then refined into monocrystalline boule. Extremely thin wafers are then cut from the silicon boules using a special sawing technique. In case of SiC, Infineon has its own laser assisted split technologies, called cold split technology, which reduces material losses significantly.

The process to manufacture chips from a wafer starts with the layout and design phase. Special design tools are used to draw up the plans for integrated circuits and develop a three-dimensional architecture of sandwiched layers. This blueprint is transferred to photomasks. Providing geometric images of the circuits, the photomasks are used as image templates during the subsequent chip fabrication process.

Cold split

- In 2018, Infineon acquired SILTECTRA GmbH, a Dresden-based start-up that has developed the innovative Cold Split technology to split silicon carbide (SiC) wafers.
- The SILTECTRA™ COLD SPLIT technology splits crystalline materials with minimal loss of material compared to common sawing technologies.
- Cold Split from Dresden will be an integral part of SiC manufacturing in Kulim
- Find out more about Cold Split here: www.youtube.com/watch?v=1U67ts5EPO0



"When it comes to the production of silicon carbide-based chips – in comparison to silicon – we can take benefit from the fact that a lot of similarities exist between the individual technologies to produce a chip. We can reuse a lot of our existing equipment, but still some very important differences remain. One is the creation of the so-called active layer on silicon carbide. This is done by an epitaxial process right at the beginning of the whole process flow, which is very much different to silicon; we need higher temperatures, different gases, different setups – this is the most striking difference in the chip production process."

Peter Friedrichs
Fellow SiC Innovation and Industrialization

"The boule splitting is specifically for silicon carbide and it is also quite limited in the world. This separation method helps to reduce the material loss from the conventional methods of using wire saw up to 50 per cent. With this loss improvement, we can take out more wafers from the same number of boules."
"This project is important to me because it's actually once in a lifetime opportunity to work on something that is very new and also is something to use my know-how to work on it and build a team together to work on something which is entirely first of a kind."

Tay Yong Kwang
Director Process Development

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Infineon’s Kulim fab in the semiconductor tree

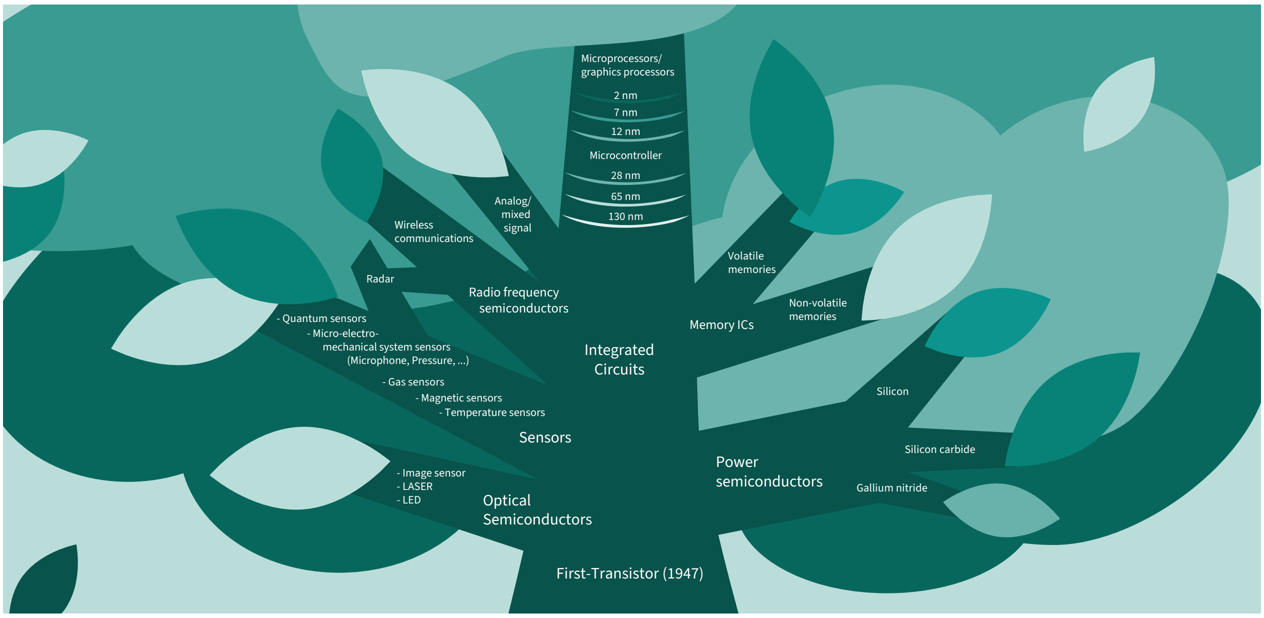
The semiconductor business is one of the most complex industries in the world. It is foundational for many other industries, for economy and for our everyday life. Based on the technology of the first transistor at AT&T Bell Labs in 1947, semiconductors have developed and diversified at tremendous speed. They are an important part to electrify and decarbonize our society.

To explain history, development and usage of semiconductors, a tree is a good picture. Its foundation is the first transistor in 1947. The different branches show the specialization, miniaturization is growing to the top. The semiconductor industry saw an unprecedented technological advancement, otherwise known as Moore's Law. It predicts that approximately every 18 or 24 months, the number of transistors on a given area doubles.

The picture shows that the world of semiconductors is vast and diversified. However, the different branches have one thing in common: power semiconductors, sensors, microcontrollers and -processors, chips on the smallest nodes as well as all the other categories in our semiconductor tree are based on enormous research efforts and knowhow.

For instance, designing and manufacturing highest performance power semiconductors requires sophisticated control of the underlying technologies and processes. The materials used to manufacture power semiconductors have evolved: whereas basic, cost-optimized devices are still made out of silicon, more advanced, energy-efficient devices require materials such as Silicon Carbide and Gallium Nitride (see chapter 03 WBG).

Infineon is one of the very few companies in the world that offers power semiconductors made out of silicon as well as silicon carbide and gallium nitride. To Infineon’s customers, it’s a great advantage to be able to pick from the right material, from the right technology for their applications.



"One way to think about the huge variety and diversity of the semiconductor landscape is to use a picture of a tree. Imagine at the root of the tree, this humble switch, which was developed in 1947 at AT&T Bell Labs, the single transistor. And now, as time passed, the technical development went into several different directions, from the trunk to the tree all the way out into the branches."

Andreas Schumacher
Head of Strategy, Merger & Acquisitions

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Epitaxy explained

Epitaxy is a demanding standard process in the semiconductor industry, where very thin layers are applied homogeneously to the wafer, usually by deposition from the gas phase. These layers are remarkably thin, often consisting of only about 5 atomic layers, and collectively make up a mere 1% of the wafer's total thickness.

Through epitaxy, the electrical properties of the material are defined. This is achieved by introducing dopant atoms into the epilayer at specific points to create source or drain wells, forming gate oxide areas, and ultimately realizing the metallization. This process enables the creation of functional semiconductor devices.

However, epitaxy becomes particularly challenging when working with gallium nitride (GaN) semiconductors. Typically, power devices are built on silicon (Si) raw wafers, but GaN semiconductors require the application of a GaN epilayer onto the Si substrate. This poses a significant challenge due to the differing lattice constants between Si and GaN, which necessitates compensating for the varying distances between Si-Si and Ga-N atoms. To bridge these differences, a wide range of dopants and multiple successive epilayers are employed.

Once the epilayers have been successfully applied, the subsequent process steps are relatively standard, as the fabrication processes for Si, silicon carbide (SiC), and GaN semiconductors share many similarities.

"Silicon carbide epitaxy is a unique process and is at the core of the silicon carbide device. Silicon carbide epi also defines the electrical properties of the device. Therefore, what is important in the silicon carbide epi is the defectivity rate. One inherent problem with silicon carbide that we needed to overcome is that silicon carbide base material has higher falls of defects, crystal defects, compared to silicon due to the complexities of the silicon carbide ball and the crystal growth."

Danny Tan
Senior Director Unit Process Development

"Silicon or silicon carbide on the one hand and gallium nitride on the other hand have different modes of epitaxy. Silicon entails 'normal silicon epitaxy', on silicon base material; it has been proven stable for many years. When it comes to silicon carbide, epitaxy is much more complex because we need a special tool to grow this silicon carbide epi on silicon carbide substrate."

Lena Tan Cheng Imm
Senior HR Director

"Epitaxy is like constructing a building, you have to prepare a ground. And this ground is the bottom layer for constructing your building."

Dr. Raj Kumar
KLM3 Project Manager & Infineon Kulim Senior Vice President, Technology and R&D

"Being able to manufacture a high-quality epitaxy is super critical and very differentiating in the market. The challenge here is that it's a very slow process to get this epi. And so therefore we need additional manufacturing capacity, especially for this epitaxy, in order to be able to fulfill the market demand and market needs, for the future."

Johannes Schoiswohl
Senior Vice President Business Line GaN

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