

Siltronic – Well positioned for the future

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May 28, 2019

Overview

Semi applications

- Semiconductor end markets growth fuelled by innovation such as Big Data, 5G connectivity, electrification, energy reduction and Artificial Intelligence

Industry innovation

- Moore's Law continues but slowing down
- Continued process technology innovation attracts new applications and increases wafer volume
- Customer roadmaps require wafers to accommodate latest Design Rules and new specifications

Stakeholder value

- We continue to execute our strategy to stay “one generation ahead”
- Grow with the market and deliver value to our stakeholders

A close-up photograph of a large, dark, circular semiconductor wafer being processed in a cleanroom. The wafer is suspended by a thin wire and is being moved by a robotic arm. In the background, a person wearing a white lab coat and a blue face mask is visible, working on the equipment. The scene is brightly lit, and the overall color palette is dominated by blues and whites.

SEMI END MARKETS

Data creation and increasing storage demand will grow further

Smartphones



- ▶ Increasing content in smartphones
 - ▶ more cameras per phone including 3D sensing
 - ▶ memory (DRAM + NAND)

PCs/Laptops



- ▶ Forecasted to remain rather flattish in silicon demand
 - ▶ upside potential with increasing SSD ratio

Servers

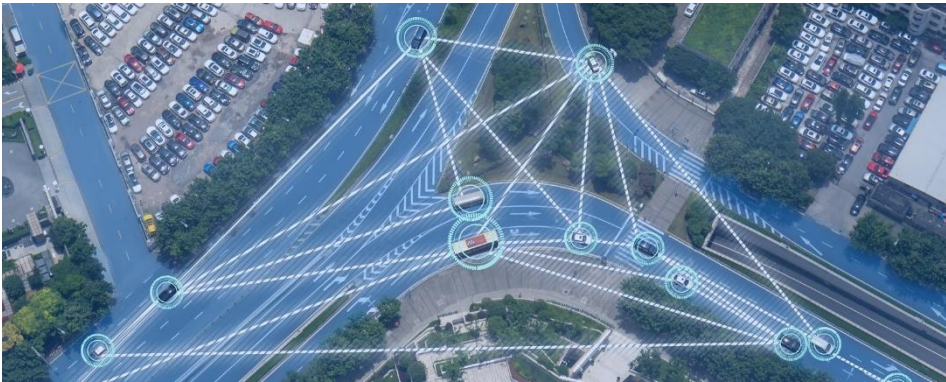


- ▶ Increasing SSD ratio and SSD size
- ▶ Substitution of HDD by SSD due to performance
- ▶ Main server applications:
 - ▶ software as a service (SaaS)
 - ▶ machine learning

Pictures: zapp2photo/stock.adobe.com, Denis Rozhnovsky/stock.adobe.com, phonlamaipphoto/stock.adobe.com

Automotive and industrial applications offer multiple growth opportunities

Automotive



- ▶ Powertrain, Chassis, Infotainment and ADAS drive Si consumption
 - ▶ Si consumption for powertrain influenced by hybrid solutions and electrical cars
 - ▶ Chassis Si consumption driven by a multitude of small devices for mechanical, electrical and sensing actions in and around the car
 - ▶ ADAS, Infotainment and connectivity require sensors, advanced Logic and larger areas of memory

Industrial

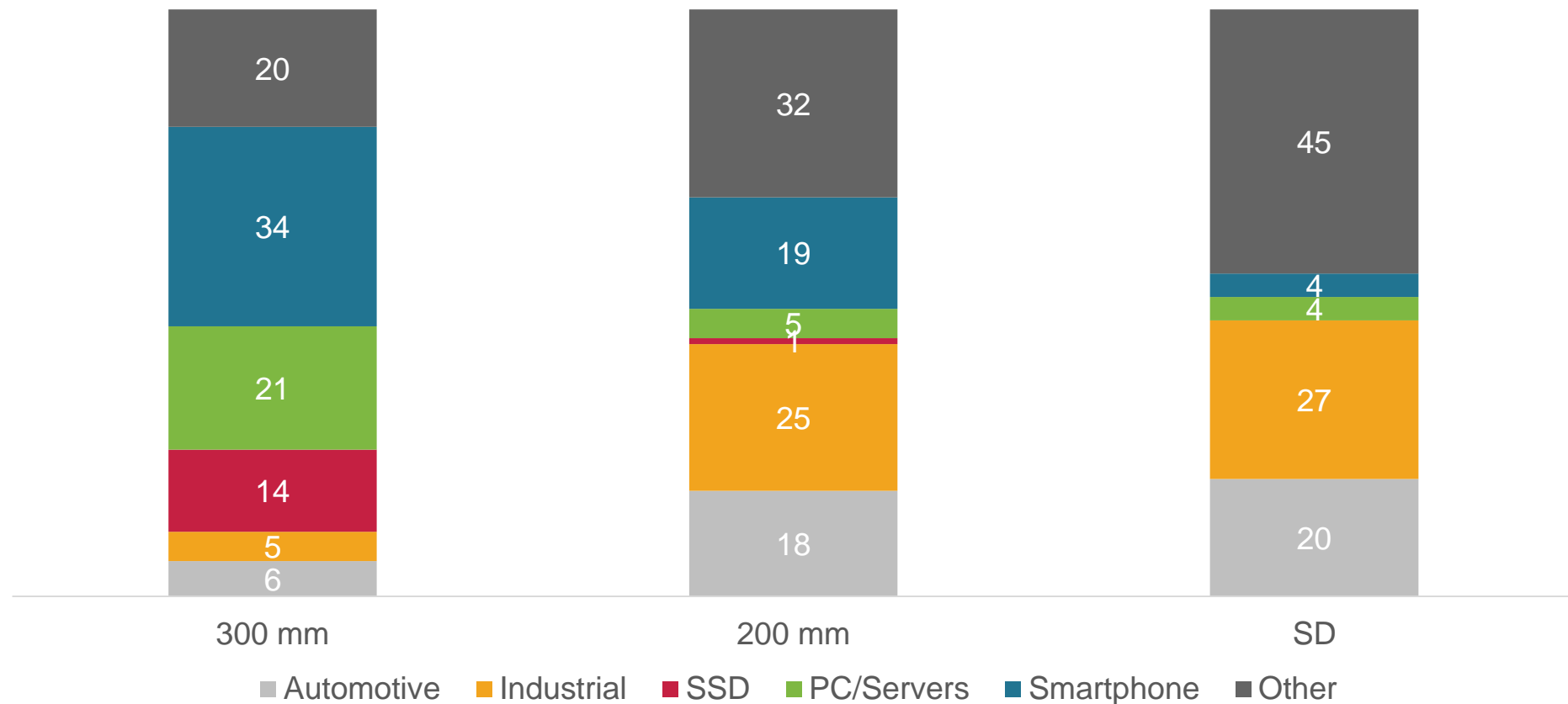


- ▶ Industrial semiconductor devices highly fragmented
- ▶ Main device groups are sensors, analog, logic and power
- ▶ Industrial devices follow the main function chain of sense - convert signal - transfer signal – process – save – and control power of the device.
- ▶ Si content growth driven by cost reduction initiatives: inverters, predictive maintenance and cobots and less by end market volumes.

Pictures: ekkasit919/stock.adobe.com, denisismagilov/stock.adobe.com

Main end applications drive different wafer sizes

Si consumption share per main end market, in % of total wafer area in 2018

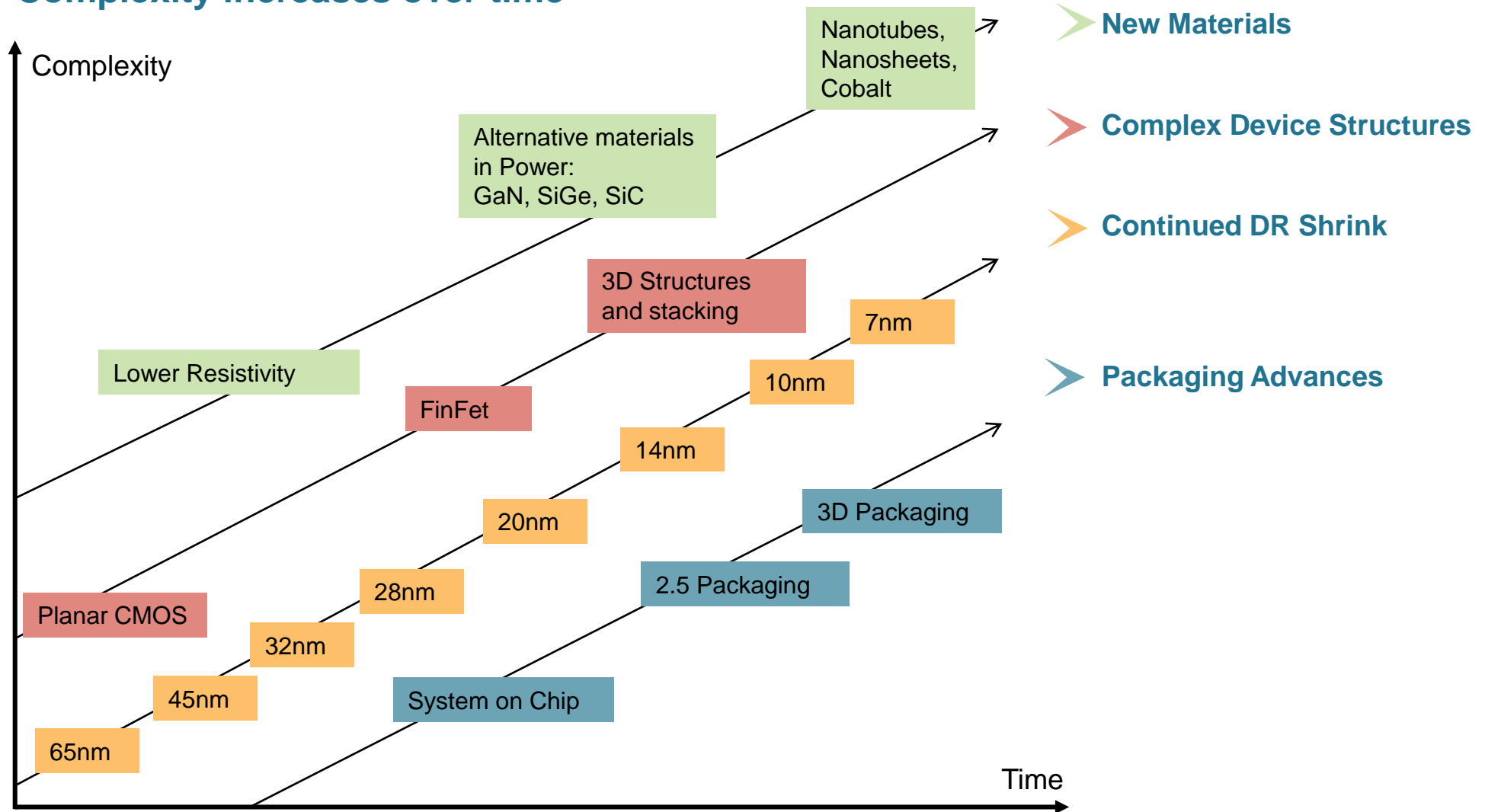




INDUSTRY INNOVATION

Diversified markets driving differentiation for silicon wafers must be fitted to varied device approaches

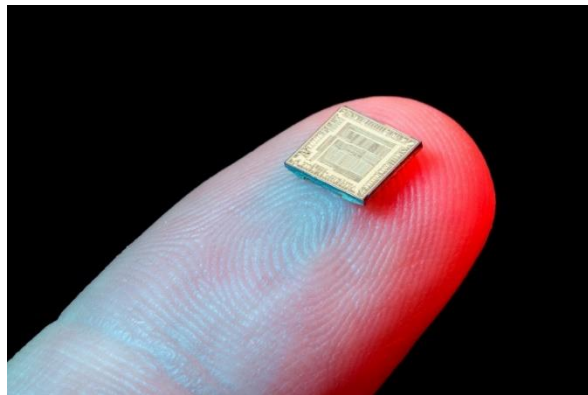
Complexity increases over time



Sources: Siltronic Marketing

Siltronic is continuously improving its wafer properties to match customer needs

- ▶ Higher integration
- ▶ Faster circuits
- ▶ Smaller transistors
- ▶ Line width reduction
- ▶ Lower power consumption
- ▶ Higher temperature
- ▶ Higher power
- ▶ Higher die yield
- ▶ Flatter wafers
- ▶ Lower defect density
- ▶ Fewer particles at smaller size
- ▶ Less edge exclusion
- ▶ Tailored resistivity specifications
- ▶ Enhanced carrier lifetime
- ▶ Advanced materials



Picture: Szasz-Fabian Jozsef/stock.adobe.com

Wafer technology requires perfection in all aspects

Example: 300 mm wafer

Clean air production environment

- For clean room class 1, <1 golf ball of “dust” would be allowed in Lake Michigan (volume ~ 5,000 km³)

Crystal perfection

- A 300 mm silicon mono-crystal with diamond lattice structure (>3 m length, >400 kg weight)

Purity of silicon wafers

- <2 unintentional metal impurities per 100 billion silicon atoms

Number and size of particles

- <5 halved golf balls within the whole New York Metropolitan area (~150 km diameter)

Flatness

- height variation of max. 1 leaf of a tree on the surface of Lake Chiemsee

Case study: yield enhancement in customer device line

Objective

- ▶ Improve device performance related to an electrical test parameter (leakage current)
- ▶ Define range / limits of dopants impurities to better understand the failure mechanism

Siltronic contribution

- ▶ Providing a sample wafer set with ingot characteristics. Physical wafer characterization and specific heat treatments to condition dopants / impurities of test wafers



Customer contribution

- ▶ Device process runs
- ▶ Feedback of electrical test parameters

Result

- ▶ **Optimized specification for certain ingot and wafer characteristics, resulting in stable and reliable yields and device performances**

Picture: Damir Fajic /stock.adobe.com

Case study: future design rule generation material and processes

Objective

- ▶ Integrate silicon wafers with non silicon channel material to achieve sub 10nm DR generation transistors
- ▶ Explore silicon wafer options based on Siltronic available products and processes

Siltronic contribution

- ▶ Hetero-epitaxial sample wafers with various SiGe layer compositions, with or without strained silicon or germanium layers. Material characterization data

Customer contribution

- ▶ Device process tests and feedback on sample wafer performance, device characterization data and assessment of applicability of different options



Result

- ▶ Early identification of potential options
- ▶ Positioning of Siltronic as development partner of choice

Picture: Vasily Smirnov /stock.adobe.com

Case study: wafer and defect characterization equipment development

Objective

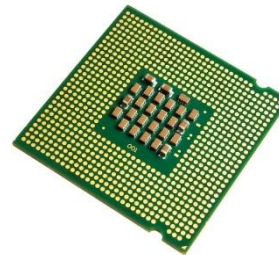
- ▶ Define and standardize measurement recipes to balance the need for sensitivity and cost optimization to enable device process development

Siltronic contribution

- ▶ Measurements with various settings, measurement capability analysis and proposals for best known method

Customer contribution

- ▶ Same as Siltronic



Result

- ▶ Aligned / correlated measurement recipes for newest generation of measurement equipment
- ▶ Ability to verify product performance against customer expectation at acceptable cost per wafer

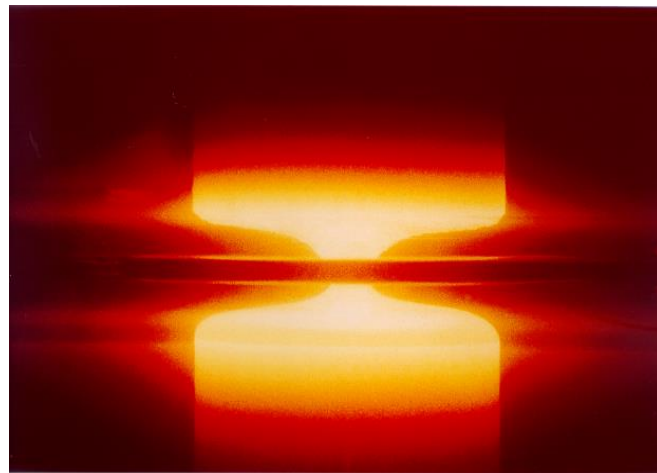
Picture: Alphonse Mc Clouds /stock.adobe.com

Czochralski (CZ) vs Floatzone (FZ) crystal growing process



Czochralski (CZ)-growth

- ▶ Whole silicon charge molten at a time
- ▶ Dopant enriches during ingot pulling in the crucible with decreasing amount of molten silicon left in the crucible
- ▶ Resistivity drops towards ingot tail end

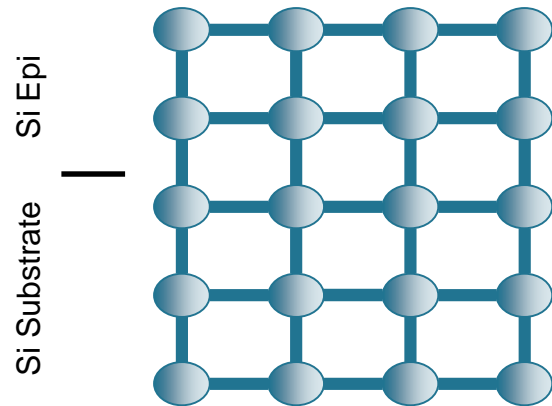


FZ-growth

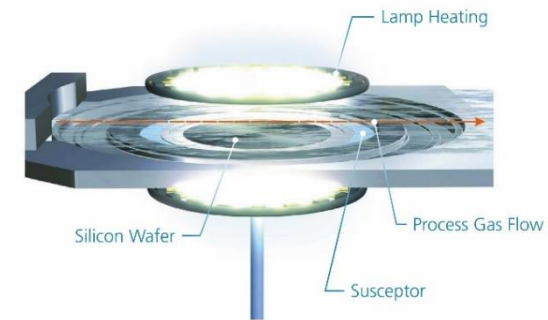
- ▶ Only a relatively small amount of silicon molten at a time
- ▶ Dopant is added as a gas blown towards the molten zone
- ▶ Hardly any axial effect

Epitaxial wafers provide perfect solution for leading edge device technologies

Homoepitaxy: „substrate layer = epi layer



Epi process step



Epitaxial layer provides

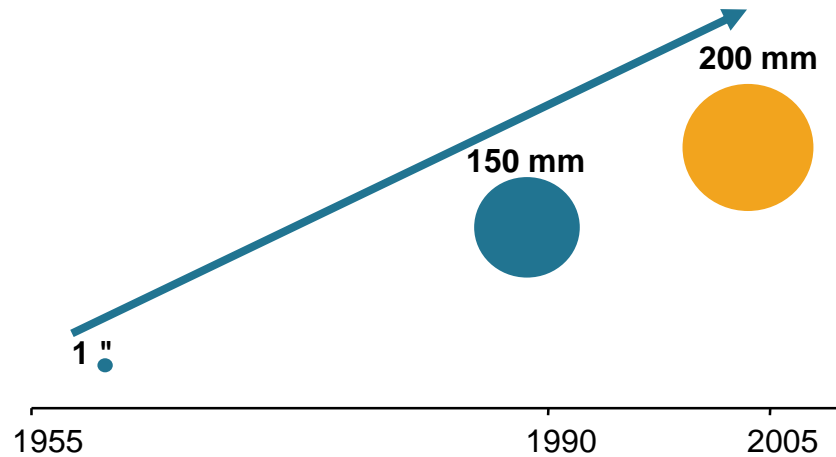
- ▶ Defect free surface and subsurface layer
- ▶ Excellent gate oxide quality
- ▶ Tighter resistivity distribution than polished wafers
- ▶ No slip issues

Target applications

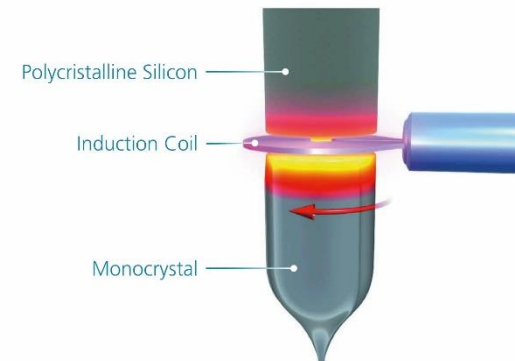
- ▶ Logic
- ▶ CMOS image sensors

Floatzone (FZ) technology

FZ development history



FZ crystal growing



Properties of FZ

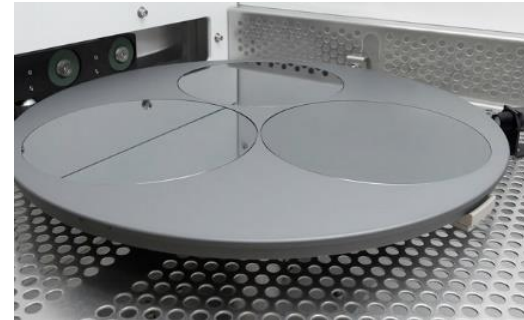
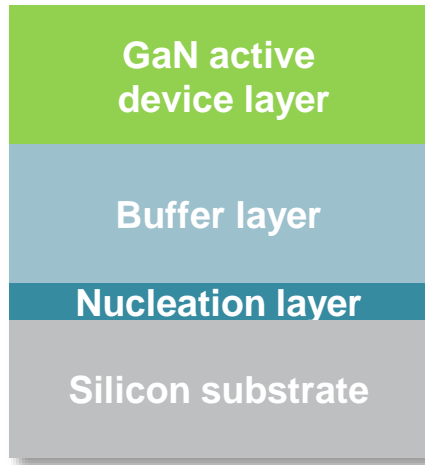
- ▶ Excellent resistivity uniformity
- ▶ Optimized purity of bulk material
- ▶ Significantly lower oxygen content
- ▶ High resistivity

Target applications

- ▶ IGBT & Diode
- ▶ Replacement for thick epi
- ▶ High ohmic applications (passive integration, RF)

R&D activities on GaN-on-Si for emerging niche markets

Structure of GaN-on-Si



8" GaN-on-Si wafer



Microscopic inspection

General benefits

- ▶ Fast switching
- ▶ Reduction of conduction and switching losses
- ▶ High temperature operation
- ▶ Compatible with Si CMOS manufacturing

Target applications

Power electronics

Low/high voltage and high frequency applications, e.g.

- ▶ Power supplies for consumer electronics
- ▶ Power converters for solar
- ▶ Devices for automotive

RF electronics

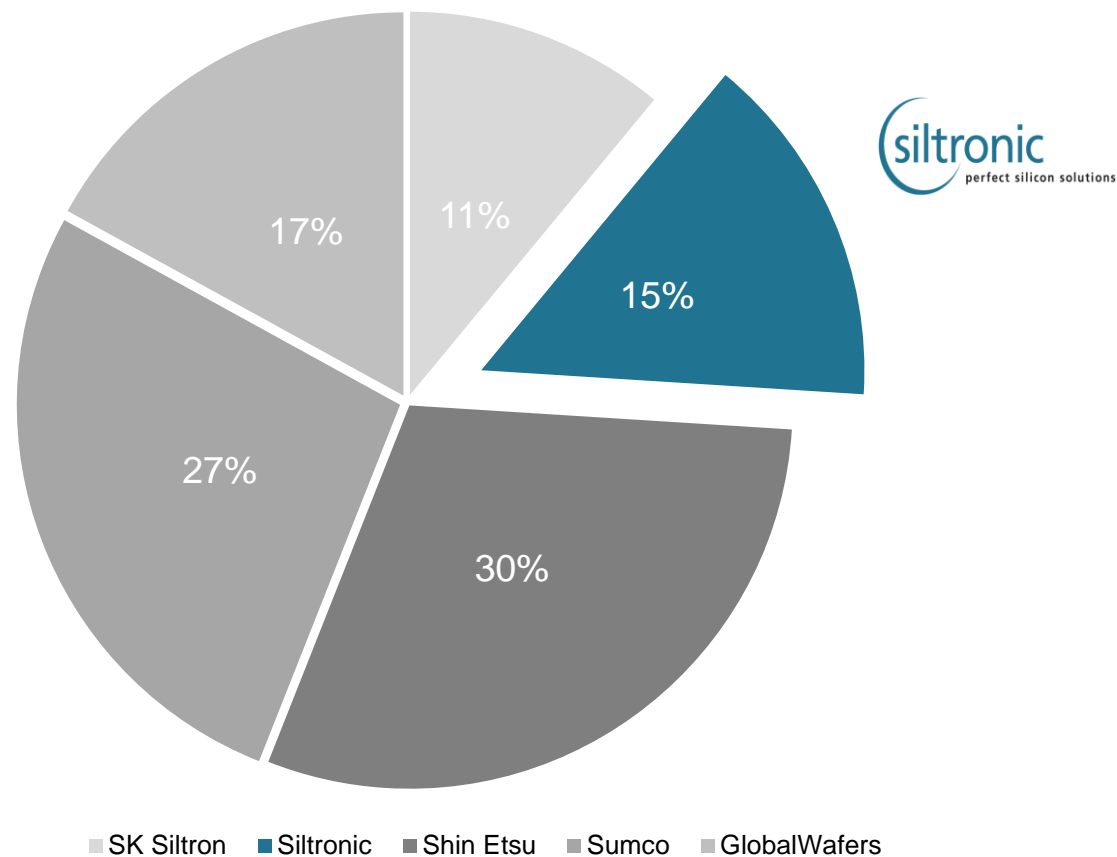
- ▶ 5G telecom infrastructure, mm wave front-end

A person wearing a white lab coat, a white face mask, and safety glasses is working in a cleanroom. They are positioned behind a large, shiny, metallic, dome-shaped object that is suspended by a thin wire. The object has a highly reflective surface, showing many highlights and reflections. The background is a cleanroom environment with various pieces of equipment and a bright, sterile atmosphere. A large, semi-transparent blue circle is overlaid on the left side of the image, containing the text "STAKEHOLDER VALUE".

STAKEHOLDER VALUE

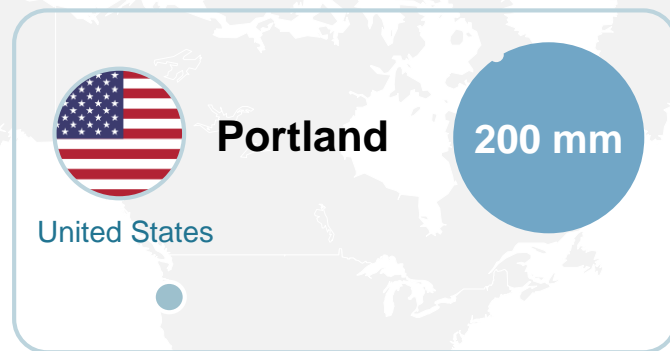
Siltronic has a relevant global market share...

Top 5 wafer producers serve more than 90% of market across all diameters

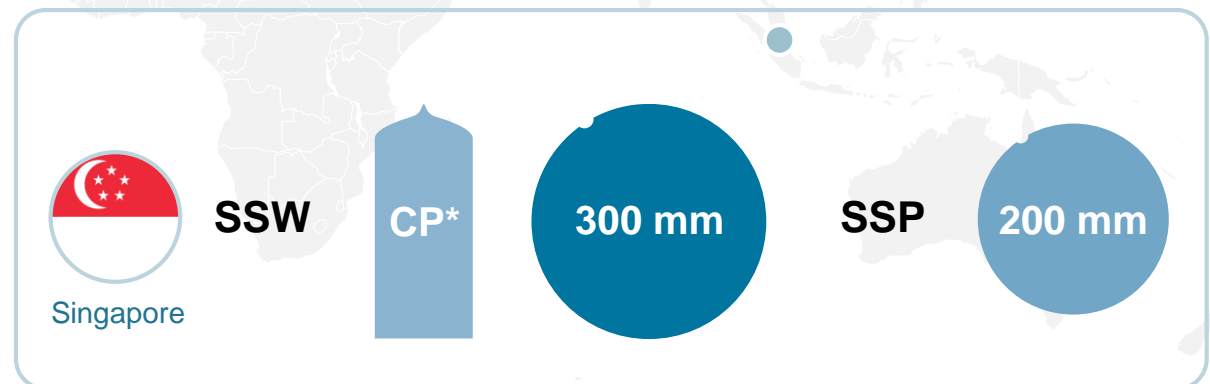
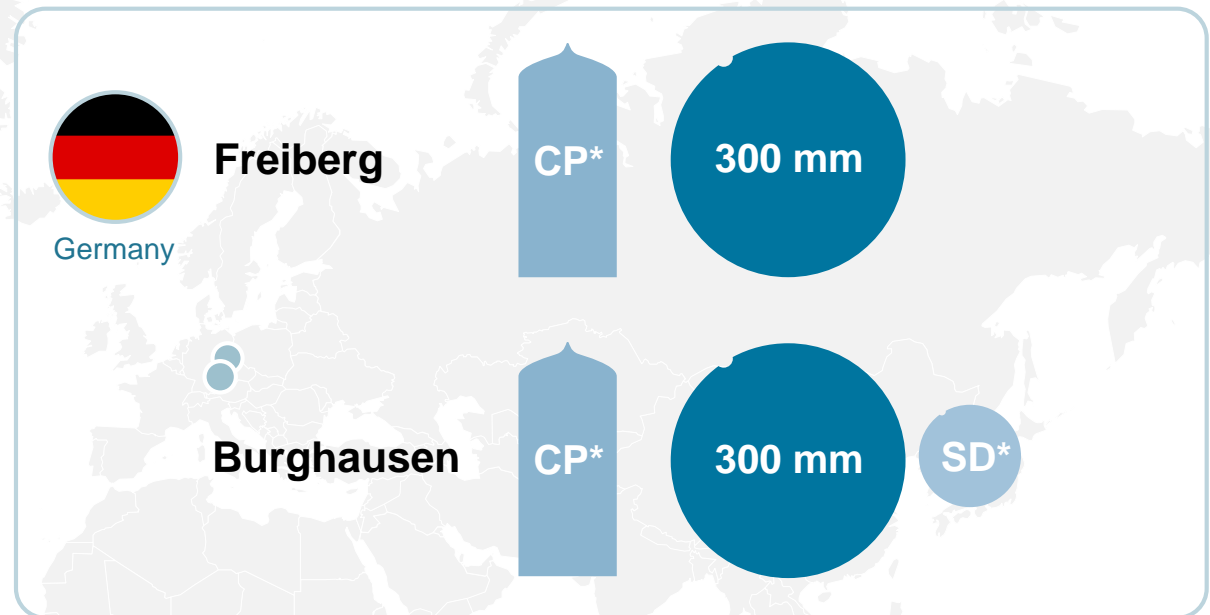


Sources: reported company revenues FY 2018, converted to USD million

... and an international manufacturing network



- ▶ **Central R&D hub** in Burghausen
- ▶ **High volume facilities** for 300 mm in Germany and Singapore
- ▶ Among world's **newest & largest fabs** in Singapore



*CP = Crystal Pulling | *SD = 150 mm and smaller

Clear commitment to sustainability

Sustainability at Siltronic AG

- ▶ **Claim:** We understand sustainability as responsible action for society and want to generate competitive advantages through sustainable action.
- ▶ **Strategy:** We plan resource-saving right from the start, based on product and production safety as well as health and environmental protection.
- ▶ **Voluntary commitments:** We follow the principles of the Sustainable Development Goals, the United Nations Global Compact, and the Responsible Care and Responsible Business Alliance initiative.
- ▶ **Goal:** We want to reconcile the effects of our business activities with the expectations and needs of society.



Responsible Business Alliance
Formerly the Electronic Industry Citizenship Coalition
Advancing Sustainability Globally



Responsible Care®
OUR COMMITMENT TO SUSTAINABILITY

Investor-Rating: Since 2018, we have been analyzed by ISS-oekom, one of the world's leading rating agencies for sustainable investments, and assessed with regard to the ESG criteria (Environment, Social, Governance). Right from the start, we were awarded 'Prime' status for our sustainability activities.



Environment - Efficiency as a success factor

Selection of non-financial performance indicators in 2018

Raw Material

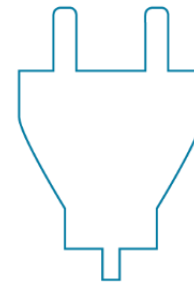


Silicon yield
improved by

1%

vs. 2017

Energy

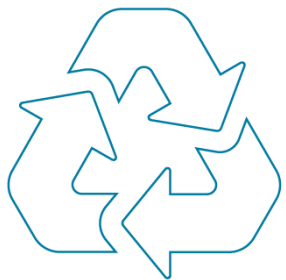


Energy consumption
per wafer area
decreased by

3 %

vs. 2017

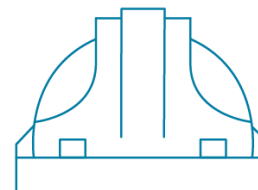
Recycling



The share of returnable
packaging per wafer
area was

32 %

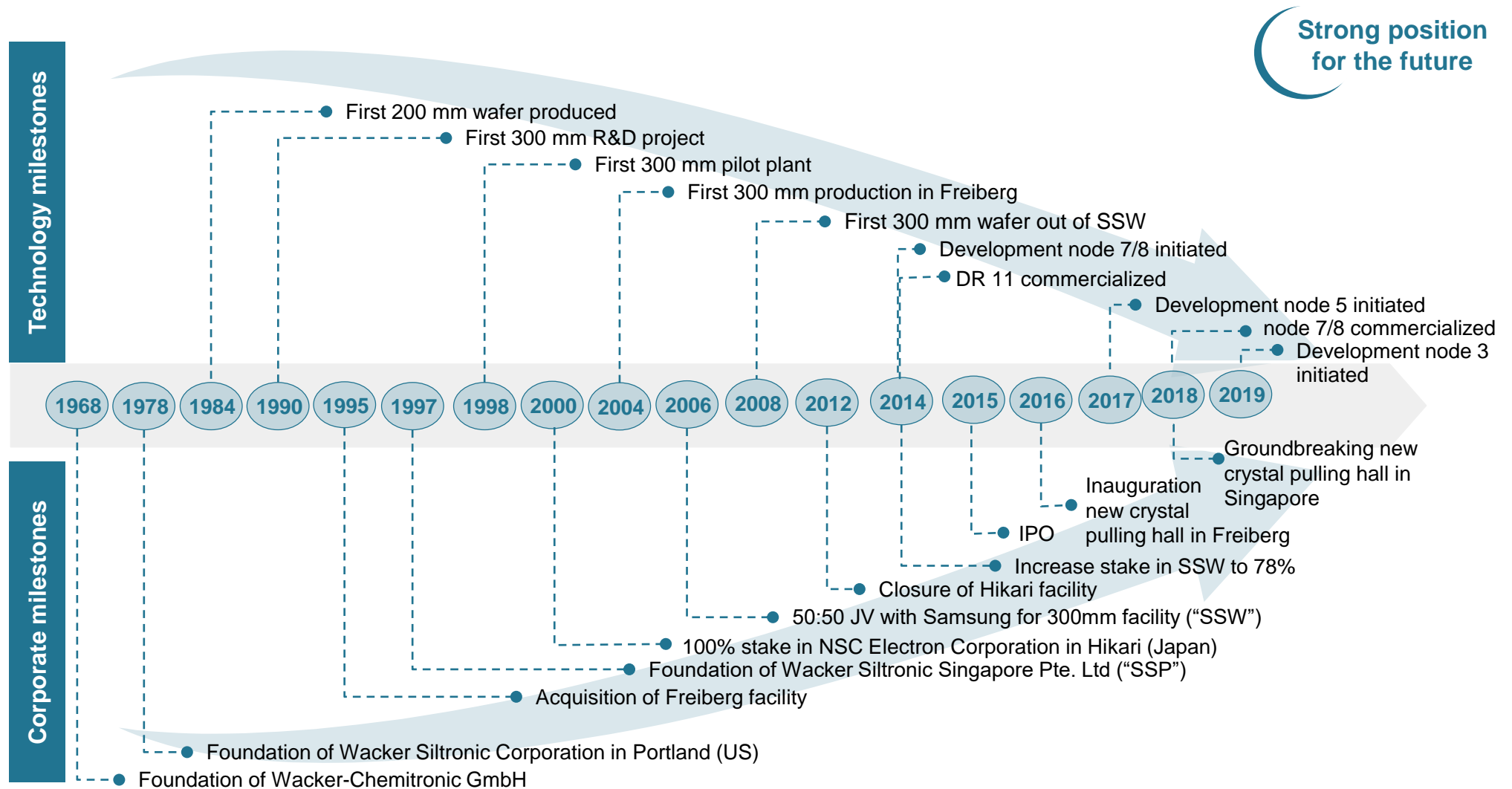
Occupational Safety



The number of accidents
at work per 1 million
hours worked was

1.9

History of technology innovation and cost optimization ideally positions Siltronic for future success



Source: Company information

Siltronic strategy - capitalize on market opportunities while focusing on 300 mm & technological leadership



**Optimize returns,
stay ahead in technology and
grow with the market**

Strategic Focus

Grow
with the market

Ensure
technology &
quality leadership

Improve
financial performance
& cash flow

Execute
cost reduction
roadmaps &
debottlenecking
concepts

We continuously increase the value for our stakeholders by providing best-in-class wafers at competitive costs.

Investment Highlights – Siltronic Strengths

Market position

- Strong market position in the semiconductor and wafer industry

Strategy

- Technology and quality leadership

Customers

- Supplier to all top 20 silicon wafer consumers

Financials

- Profitability increase and on-going efficiency improvement

Products

- High-quality wafers made of hyperpure silicon

Management

- Experienced management team and highly skilled workforce

Contact and Additional Information

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Additional Information

| | |
|-----------------|--|
| ISIN: | DE000WAF3001 |
| WKN: | WAF300 |
| Deutsche Börse: | WAF |
| Listing: | Frankfurt Stock Exchange Prime Standard |

Financial Calendar

| | |
|------------------------|------------------|
| Half Year Report | July 25, 2019 |
| Q3 Quarterly Statement | October 24, 2019 |



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