OKMETIC

High-performance silicon wafers for MEMS, RF and power devices

OKMETIC
ADVANCED SILICON WAFERS SINCE 1985

Leading supplier of advanced silicon wafers for MEMS, sensor, RF and power devices

Focusing on high value-add, specialized 150-200 mm wafers:

- Magnetic CZ (MCz), A-MCz®
- Bonded SOI with & without Cavities
- Patterned wafers
- Very Low and Very High Resistivity (RFSi®)

Okmetic

- HQ and production in Finland
- Sales and Tech support worldwide

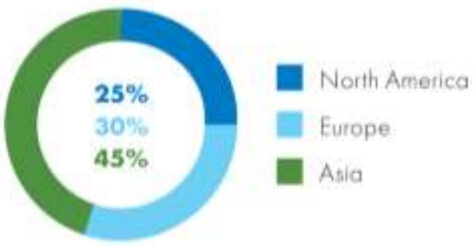
NET SALES in 2022	INVESTMENTS for fab expansion	PERSONNEL
146 M€	~400 M€	~ 640

OKMETIC

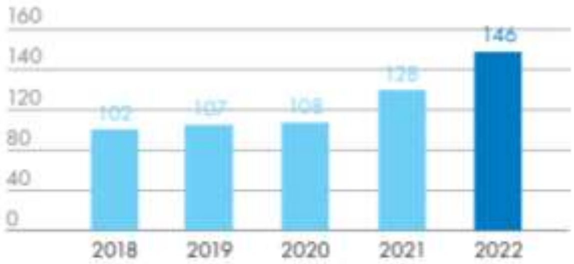
Year 2022 in brief

- Net sales and number of employees were record high
- In May we announced a 400Meur investment in fab expansion, that will more than double the production capacity
- We continued our active cooperation in multilateral R&D projects with Finnish and international universities and research institutions

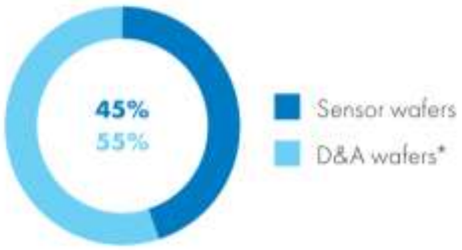
NET SALES PER MARKET AREA



NET SALES (MILLION EURO)

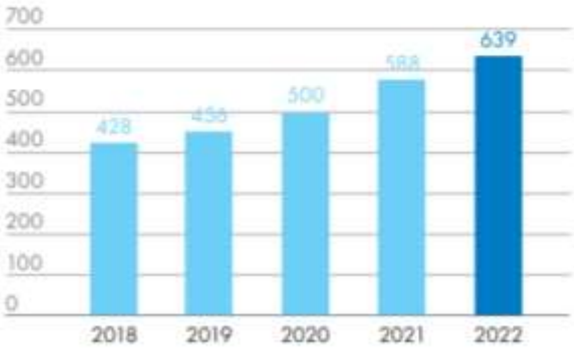


NET SALES PER CUSTOMER AREA



*D&A (Discrete and Analog) includes wafers for RF filters and devices as well as for power devices.

PERSONNEL



Okmetic milestones

1985 Foundation of Okmetic Oy, a joint venture of Nokia and Outokumpu

1987 Industrial production of silicon wafers in Espoo, Finland

1997 Start of new crystal and wafer plant in Vantaa, Finland

1999 Okmetic Inc. founded in the US

2000 Okmetic listed on the Helsinki Stock Exchange

2001 SOI wafer volume production started

2006 Sales office Okmetic K.K. founded in Japan

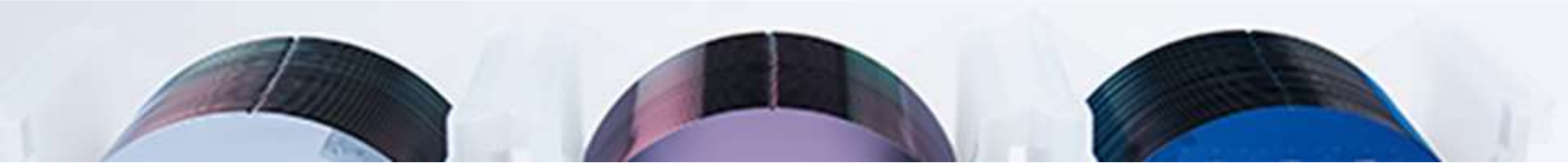
2011 Asia-Pacific sales office established

2016 NSIG new owner, delisting from Nasdaq Helsinki

2019 Fully in-house C-SOI® mfg. in Vantaa, Finland and establishment of sales office in Germany

2020 Doubling of SOI capacity

2022 400 million Euro investment for fab expansion announced



OKMETIC

Focusing on sensor, RF and power industries

- **Sensor industry (45% of net sales)**
  - Advanced wafers (SOI and Patterned wafers) for MEMS and other sensors
- **RF and Power industries (55% of net sales)**
  - High resistivity RFSi® wafers for RF filters and devices
  - Low and medium resistivity wafers for power devices

OKMETIC

Complete set of 150-200 mm wafers enable optimized solutions and freedom of design

SOI wafer line

High Resistivity

RFSi® wafer line

Wafers for Power

Patterned wafers

SSP wafers

DSP wafers

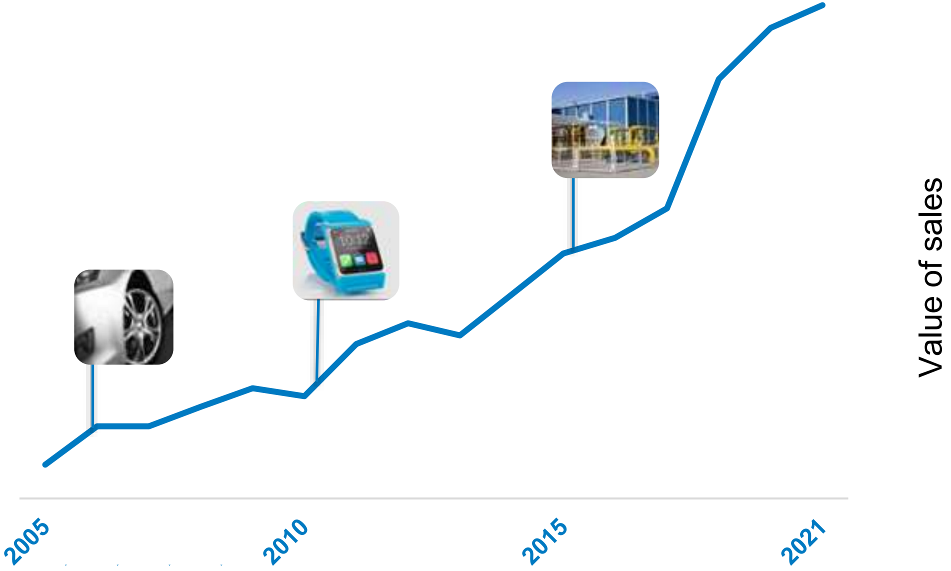
TSV wafers

Customized solutions

- Different crystal materials, dopants and orientations
- Resistivities below 1 mOhm-cm and beyond 10 kOhm-cm

Over 20 years of Okmetic SOI wafers: MEMS continues to be growth driver but use in other markets increasing

2023 Launch of Terrace Free SOI capability
2021 Okmetic SOI 20th anniversary
2020 EC-SOI combining E-SOI® and C-SOI® benefits
2019 New C-SOI® production line in 2019
2016 Launch of E-SOI®
2015 SOI wafers for power management
2010 Extremely small pressure sensors and wearable electronics
2009 C-SOI® in volume production
2006 C-SOI® -based inertial sensors for automotive industry
2005 First C-SOI® deliveries
2001 SOI wafer production line started



There’s now plenty more BSOI and E-SOI® capacity available as a result of SSP line renewal

→ Let’s review new business opportunities

Large Bonded SOI product family in 150-200 mm – Solutions for various needs

BSOI wafers – fully customizable with thick or thin device layer

0.3 SOI | D-SOI | L-SOI

> Traditional MEMS devices

NEW capability:

Terrace Free BSOI and E-SOI® wafers

E-SOI® wafers – highly uniform device layer with ±0.1 µm thickness variation

> Silicon photonics, high-precision silicon-based MEMS and BCD devices etc.

C-SOI® wafers – SOI with embedded/buried cavities

EC-SOI | Double C-SOI® | C-SOI® with patterned device layer | C-SOI® wafer with poly via | LT-C-SOI

> Pressure and inertial sensors, silicon speakers, and microfluidic devices etc.

Tailored substrates

BSOI

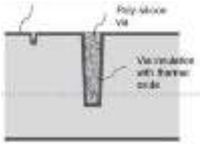
- Fully customizable with starting materials from in-house crystal growth and wafering

E-SOI®

- Highly uniform wafers with tight ±0.1 µm device layer thickness tolerance not dependent on device layer thickness

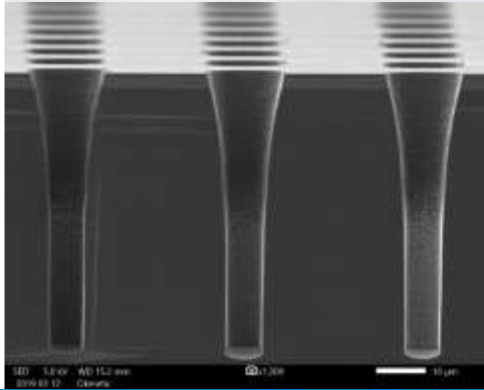
C-SOI®

- Wafers with pre-etched cavities



TSV

- Through silicon vias for sensor interconnects



Bonded SOI wafers give more freedom to device design

A lot of design freedom via wide selection of crystal properties, and bonding and thinning -based SOI process that enables device layers much thicker than competing SOI technologies.

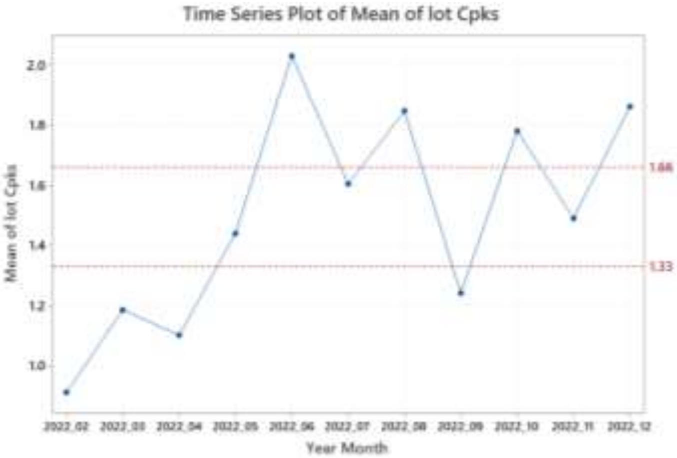
Device layer
Thickness between 1.0 µm and > 200 µm
Tolerance ± 0.5 µm

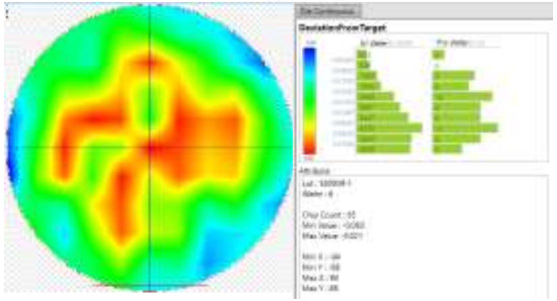
Buried oxide layer
Thickness between 0.3 µm and 4 µm, typically between 0.5 µm and 2 µm

Handle wafer
Thickness between 300 µm to 950 µm, typically 725 µm in 200 mm wafer and 380 µm in 150 mm wafer

Wide selection of dopants, orientations and resistivities for device and handle layers

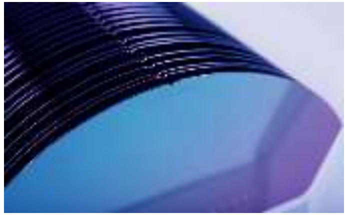
Example of Cpk ramp-up of a customized E-SOI® wafer with non-standard handle and total wafer thickness





- Okmetic started a customized 200 mm E-SOI® wafer project with non-standard handle and total wafer thickness in February 2022
- 100% sorting with 65 pt device layer thickness measurement pattern was used
- Based on the target ±0.1 µm specification and all the 65 measurement points within the wafer used
    - Initial Cpk was ~1 with some yield losses
      (Cpk = Process Capability Index)
    - Cpk of >1.33 was quickly reached after process was optimized for the new wafer thickness → This ensured high productivity and yield for the E-SOI® wafer with non-standard handle and total wafer thickness.

Power wafer line in 150-200 mm – Optimized to reduce power losses



Discrete Power Device wafers

Freely adjustable wafer parameters and down to < 0.001 Ohm-cm resistivity

- Discrete power devices (IGBTs and Power MOSFETs with low on-resistance)

Power Management SOI wafers

Bonded SOI wafers with down to < 0.001 Ohm-cm resistivity, tight resistivity control, low and controlled Oi levels and zero BMDs

- Gate drivers for power devices, Battery and Power Management ICs, Intelligent Power Modules, and other Smart Power devices using advanced BCD or BiCMOS processes

Power GaN Substrate wafers (Si)

From standard to extra thick <111> Si and SOI wafers with advanced stress management for GaN growth. Customized for GaN-on-Si and GaN-on-SOI power device needs.

- Highly functional and cost-effective challenger for GaN-on-SiC substrates. Suitable for GaN HEMT devices

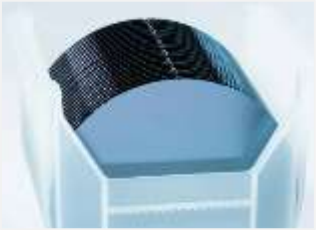
RFSi® wafer family in 150-200mm – High Resistivity for RF device needs

High Resistivity wafers

- Up to > 7 kOhm-cm resistivity without trap-rich layer, low loss **RF IPD** or **Integrated RFFE / RFIC** substrate

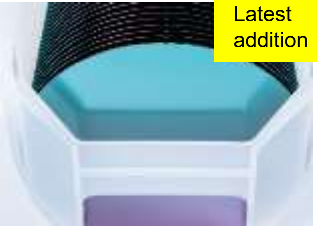
Engineered High Resistivity wafers

- Up to > 7 kOhm-cm resistivity with added trap-rich layer for extremely low loss subtrate for **RF filter devices**



UF-RFSi® wafers

- Engineered low loss substrate with Up to > 7 kOhm-cm resistivity, trap-rich layer and Ultra Flat properties for e.g. **Thin Film SAW**



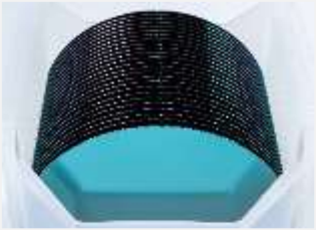
Latest addition

Engineered Ultra High Resistivity wafers

- Over 10 kOhm-cm resistivity and added trap-rich layer, close to zero-loss substrate for **RF filter devices**

High Resistivity SOI

- Bonded - BSOI or suspended C-SOI® low loss structures per Customer design, e.g. **BAW** resonator



RF GaN Substrate wafers

- Typically extra thick <111> MCz wafers **GaN-on-Si RF Power device** substrate with advanced stress management

Supporting customers worldwide

EUROPE (~30% of net sales)

- HQ, plant, sales and technical support in Vantaa, Finland
- Sales office in Germany

ASIA (~45% of net sales)

- Sales offices in Japan and China
- Sales representatives in Korea, Malaysia, Singapore and Taiwan
- Technical support in Japan and China

NORTH AMERICA (~25% of net sales)

- Sales office, technical support

Production facilities – Vantaa site and subcontracting

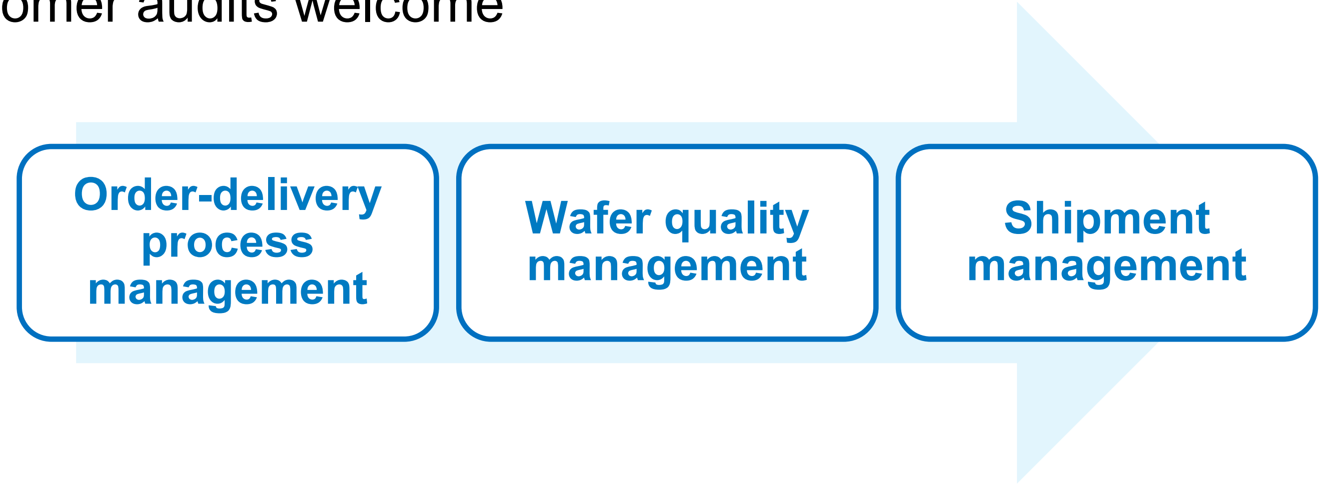
Vantaa site, Finland

- Crystal growing
- High-value added 150-200 mm wafer production
- Fully in-house BSOI and C-SOI® line
- Around 400 MEUR investment for fab expansion to double the capacity
  - Focus on 200 mm SSP and DSP and crystal growing capacity
- Over 100 MEUR investments in 2017-2021

Wafering subcontractors in Asia

Fab lite model – important part of Okmetic's production strategy for over a decade

- Okmetic manages the supply chain and customer relations
- Fab lite partners with all quality and environmental certificates
- Customer audits welcome



Order-delivery process management

Wafer quality management

Shipment management

Okmetic’s strengths

Crystal growing

High-performance wafer manufacturing

Agile supply chain

Customer relations

Quality and sustainability

Quality and environmental certificates

Conflict Minerals Statement
Halogen Free Compliance

ISO 9001 &
ISO 14001
recertification

RBA VAP &
REACH
recertification

IATF
recertification

Okmetic quality system has been tested

Positive feedback from audits:

- Quality system reliability
- Highly motivated and qualified team
- Good management attendance
- Co-operative and transparent communication and information sharing
- Process quality focus areas
- Okmetic MES (Manufacturing Execution System)

Three VDA 6.3 audits with an average score of 96% in 2022

Sustainability

- Documented management system established in 2017
  - Corporate Social Responsibility Policy
  - Okmetic Corporate Social Responsibility Manual
  - Ethics Channel guide
- Okmetic passed the Responsible Business Alliance audit in Feb 2023

RBA Code of Conduct

Okmetic has adopted The Responsible Business Alliance's (RBA) Code of Conduct as a guideline for its sustainability operations. We prepare our annual Sustainability Report in accordance with this model.

- Our Sustainability manual has instructions for the entire personnel on how Okmetic complies with the Code of Conduct
- We participate in the RBA Validated Audit Process
- We use Sales Assessment Questionnaire (SAQ), which is filled out yearly
- We also require our suppliers to accept the principles of RBA's Code of Conduct.

Picture: RBA

Responsible Business Alliance certificate

- Okmetic RBA certificate was renewed on March 8, 2023
- We have achieved Silver Status with a score of 183.5

Responsible Business Alliance
Advancing Sustainability Globally

Recognition that

Vantaa plant

Piitie 2 , Vantaa, , 01510
Finland

Completed the RBA Validated Audit Process, achieving SILVER Status without any priority findings, earning a score of 183.5

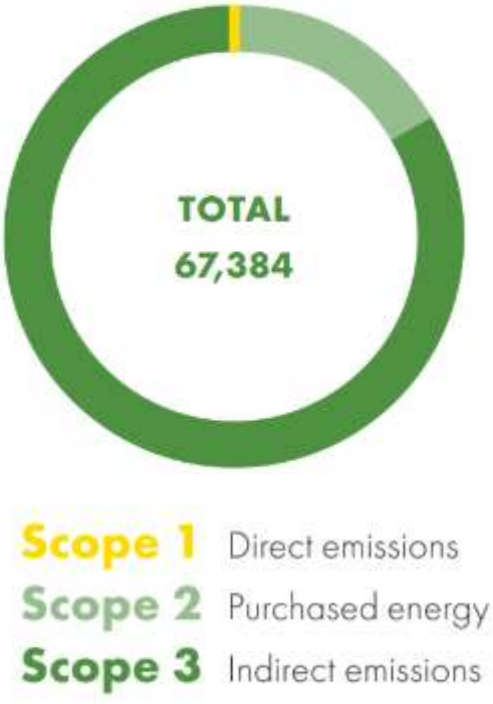
Validated Audit Report: VAR-20230215-FI-02A01-1
Audit date: February 15, 2023
Certificate issue date: March 8, 2023
Expiration date: February 16, 2025

Robert F. Lederer
CEO, RBA

Sustainability reporting

- Okmetic Sustainability Report follows the GRI standard
  - GRI (Global Reporting Initiative) is the independent, international organization that helps businesses and other organizations take responsibility for their impacts, by providing them with the global common language to communicate those impacts
- Emissions reduction roadmap has been published in Q2/23.
- 2022 Sustainability report and emissions reduction roadmap have been published and can be found here
- Our carbon footprint is estimated with Scope1, Scope2 and Scope 3 calculation

Carbon footprint calculations finalized



- Scope 1 42 tCO2e
  Direct emissions –
  Production plant and company owned vehicles
- Scope 2 11,105 tCO2e
  Purchased energy –
  Electricity and heat
- Scope 3 56,237 tCO2e
  Indirect emissions –
  Arising from the company’s value chain, sold products not included

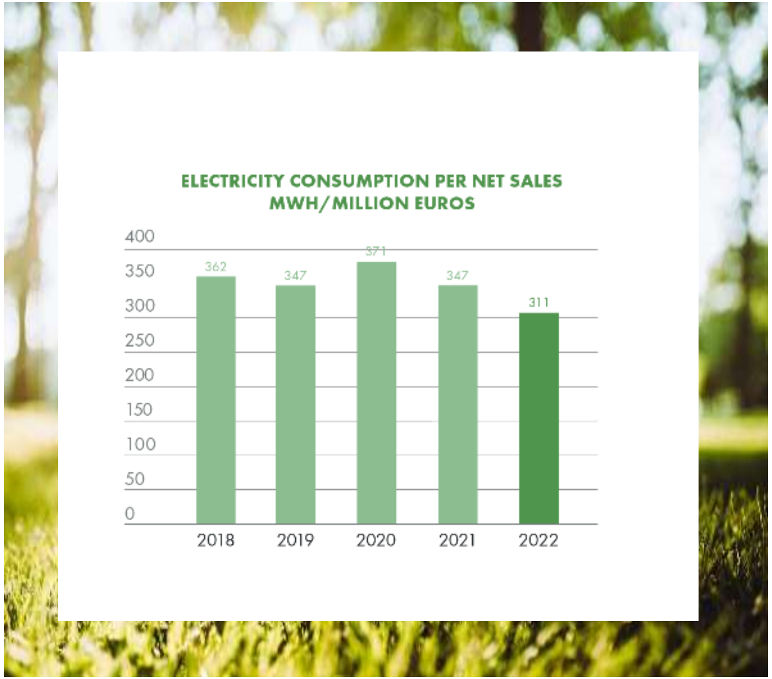
Okmetic aims to reduce Scope 1&2 emissions by 90 %

- Gradually increasing share of carbon neutral electricity
- Implementing heat recovery projects
- Installing rooftop solar panels

Responsible production of high-performance silicon wafers

- Okmetic has recognized environmental aspects of silicon wafer production already at the construction stage of the Vantaa plant and takes them into account in its daily operations
- Environmental risk identification and management encompass the entire company’s operations as well as individual processes. Preventive planning is an important aspect in the management of environmental risks
- Energy consumption, use of polysilicon, the amount of mixed acid waste as well as water and chemical consumption have all been identified as significant environmental factors in the company and are regularly measured and monitored

Electricity consumption

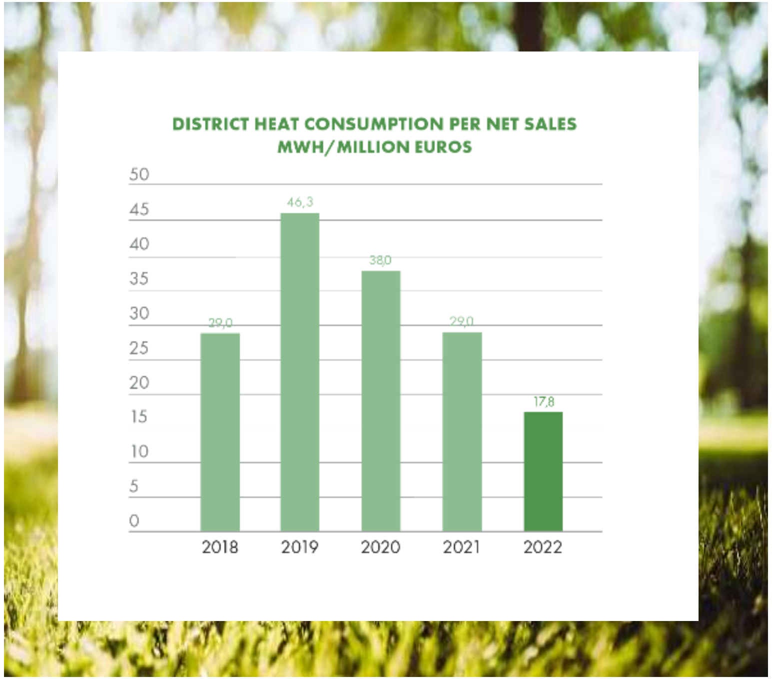


Electricity consumption per net sales has been significantly reduced in recent years:

Actions taken in 2022:

- A project started in 2021 to replace the plant lighting with LED lights continued
    - By the end of 2022, LED lights had been installed in 98 % of the plant area.
- In 2022 we conducted a development project that reduced the amount of electricity consumption in crystal growing by 10% per amount of silicon used
- The plant capacity utilization has been high, leading to good efficiency in electricity use

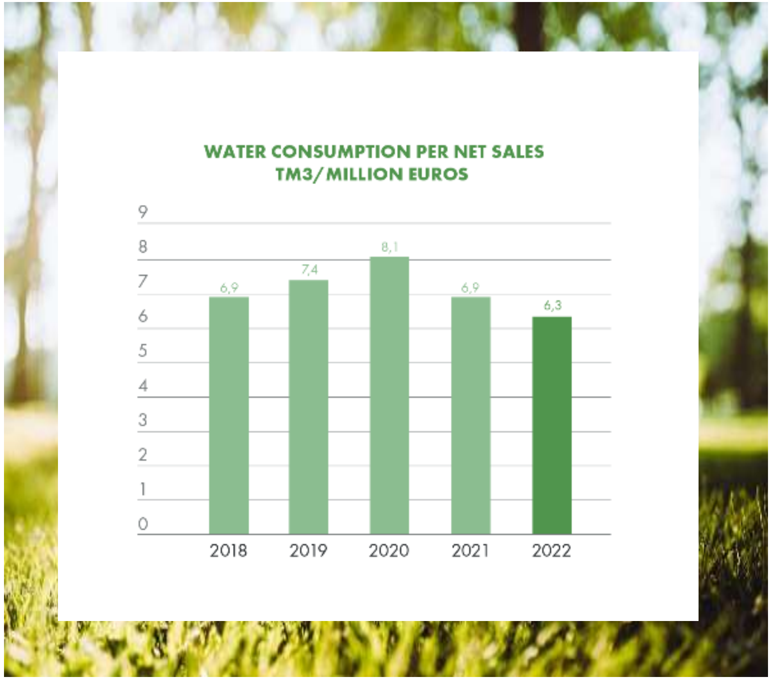
Heat consumption



District heat consumption depends heavily on the outside temperature.

Year 2022 was warmer than previous years and therefore heat consumption was lower.

Water consumption

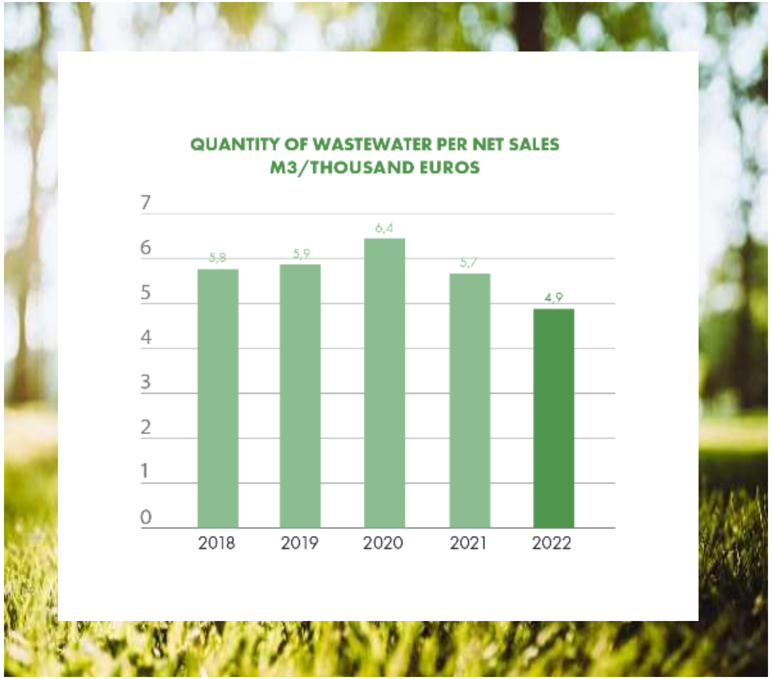


Water consumption per net sales is declining.

Actions taken:

- In 2022 we carried out a research project that calculated water consumption in production. The goal is to find ways to reduce water consumption
  - Based on the results we are creating a plan in 2023 for reducing water consumption
- The plant capacity utilization has been high, leading to good efficiency in water consumption per wafer
- Water recycling in several work phases
  - Recycling rates are being calculated in 2023

Amount of wastewater

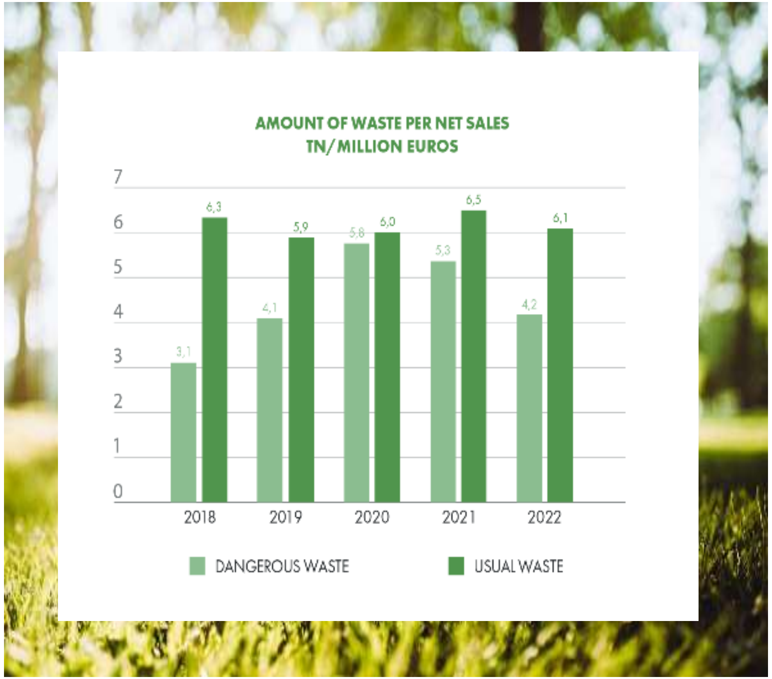


Amount of wastewater per net sales is declining.

Actions taken:

- Wastewater amount control limits are in line with the industrial wastewater agreement
- Wastewater amount is controlled by regular measurements
    - 24-hour measurement 6x year at 3 different measurement points

Waste and dangerous waste



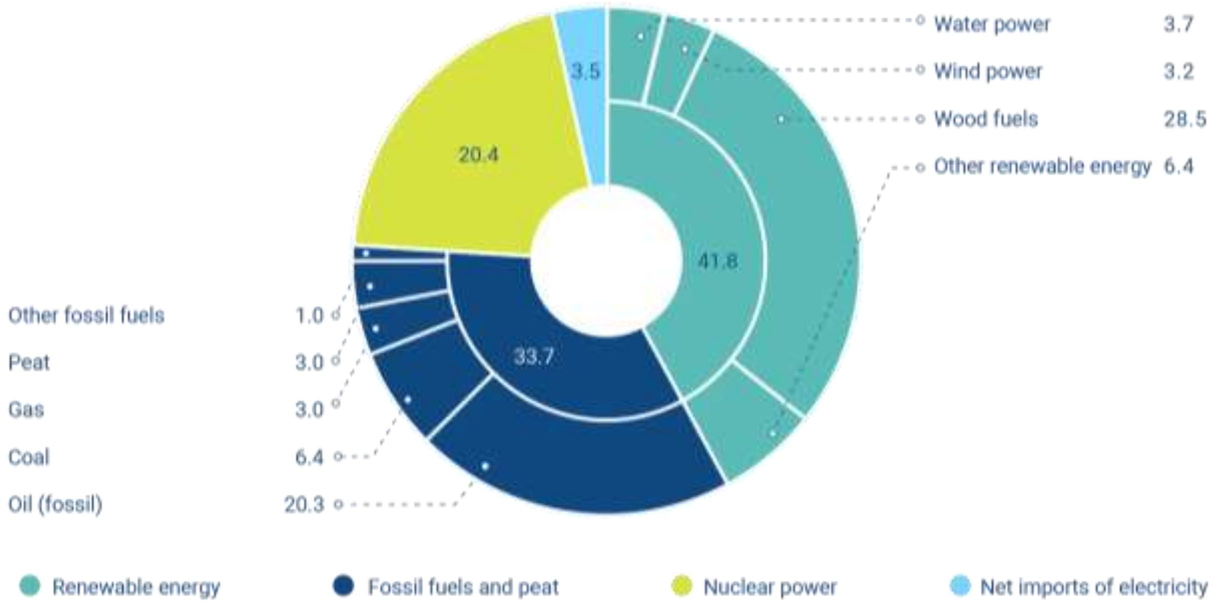
The amounts of waste and dangerous waste are declining after the rise resulting from the induction of new acid etching tools in 2019.

Actions taken:

- Reducing the chemical consumption of the new acid etching tool
- Reducing chemical consumption and the amount of waste
- Optimization of acid usage

Total energy consumption in Finland by energy source in 2022

- In 2022, Finland’s total energy consumption decreased by five per cent compared to the previous year.
- The share of renewable energy sources of the total energy consumption in Finland was 41.8% in 2022

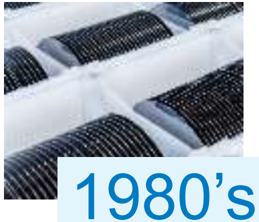


Source: Statistics Finland

Additional Okmetic slides

A pioneer and leading supplier of tailored silicon wafers since 1985

Continuous R&D: crystal growth, SOI wafers, 200mm wafers



1980's

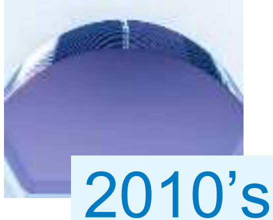
- First (DSP) wafers for pressure sensors

1990's

- Qualified supplier of (DSP) silicon wafers for automotive industry in the US
- MCz-based wafers for sensors

2000's

- Silicon microphones (SSP, SOI)
- SOI wafers (C-SOI®) for automotive industry and for inertial sensors



2010's

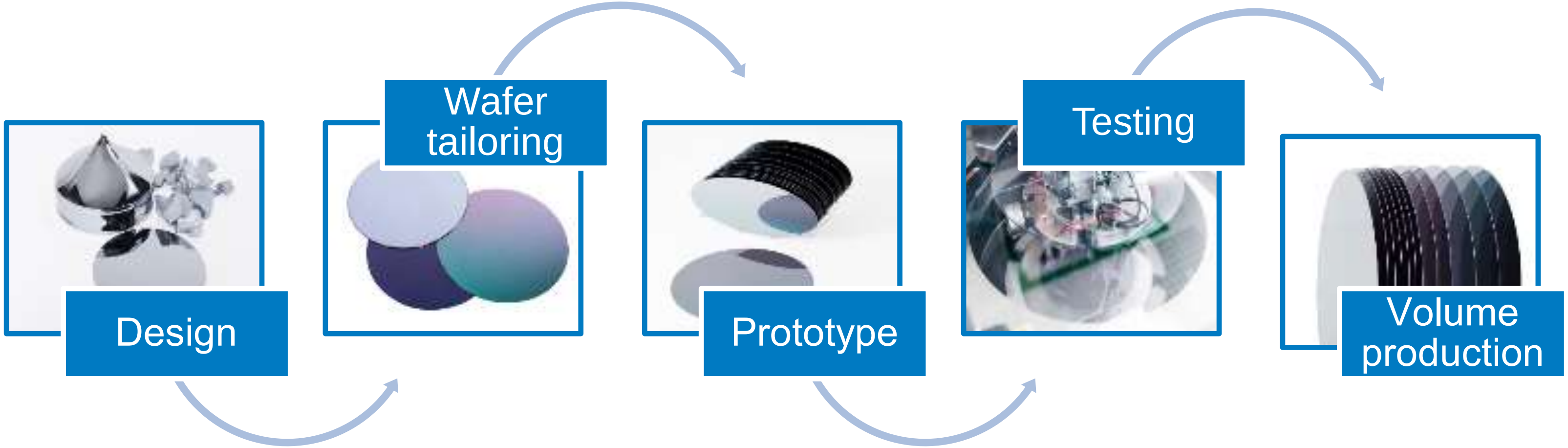
- Extremely small pressure sensors (E-SOI®)
- Wearable electronics
- Polysilicon TSV
- A-MCz® and RFSi® wafers for RF integration

2020's

- RF filters and devices (UF-RFSi® for TF-SAW)
- Engineered Ultra High Resistivity wafers
- Terrace Free SOI capability

Known for commitment and long-term partnership

Benefits: cost reduction, faster cycles, shorter time to market and process streamlining



Design

Wafer tailoring

Prototype

Testing

Volume production

Okmetic is a part of both Finnish and European semiconductor community

- Okmetic is part of the growing Finnish and European semiconductor ecosystem
- Active collaboration and joint projects with Finnish and European semiconductor cluster and educational institutes create:
    - High-productivity jobs
    - Significant export income
    - International investments
- Okmetic headquarters, decision-making and production in Finland (extensive fab expansion investment underway)
- We comply with the Responsible Business Alliance's Code of conduct, and sustainability is a key factor in all our actions defined by the RBA (Environment, Labor, Health&Safety, Ethics)

Resilient supply chain

- Business continuity and supply chain is secured in all scenarios, we are prepared for possible supply chain disruptions
- Sufficiency of raw material and production consumables secured
  - Expanded supplier base (qualified suppliers)
  - Long-term delivery contracts
  - Increased stock and consignment stock
  - Preordering

Sustainability: Okmetic carbon footprint calculations & emissions reduction roadmap

Okmetic's carbon footprint calculations 2022

Scope 1	42 tCO2e
Scope 2	11,105 tCO2e
Scope 3**	56,237 tCO2e

Actions for reducing CO2 emissions

- Gradually increasing share of carbon neutral electricity
- Implementing heat recovery projects
- Installing rooftop solar panels

** Scope 3 not including sold products

Supporting growth: Investments in infrastructure and talent pool

Investments in Vantaa site, Finland

- Around 400 MEUR investment for fab expansion to more than double the capacity
    - Focus on 200 mm SSP and DSP and crystal growing capacity
- Over 100 MEUR investments in 2017-2021

We collaborate actively with semic companies and educational institutions to promote the semiconductor industry

- In early 2023, we donated to Aalto University, to increase various engineering summer jobs for students
- Vocational training programs

Photo: Fab expansion June 2023

Fab expansion – status update

Fab expansion proceeding on schedule

Actions in 2023:

- Drill piling (readiness end of 2023: 100%): DONE
- Foundation base construction (100%) ONGOING
- Underground pipe work (100%) ONGOING
- Framework installation (100%) ONGOING
- 110kV electric supply cables (100%) ONGOING
- Steel frame installation (100%) ONGOING
- Facade element installation (100%) ONGOING
- Water ceiling constructions (100%)
- Partition (wall) constructions (50 %)
- HVAC and plumbing installations (30 %)

Photo: Fab expansion June 2023

Most tools ordered or selected

- The fab expansion will be using same or similar kind of state-of-the-art equipment and production lines as are in use at the existing Vantaa fab premises.
- Okmetic demand mix forecasts with determinations related to wafer parameters has guided tool acquisitions.
- Most tools have been ordered or selected and lead times are as scheduled.
  - Tool supplier meetings are held regularly.

Recruitment and induction plans

- Recruitments for the fab expansion team is well underway.
- The recruitment of operators has started. Around half of the operators will be recruited for the current fab premises and half for the fab expansion.
- Holistic work induction and training plan has been implemented and first trainings have been held.
    - Induction will be carried out separately for each work phase by operator trainers.
    - In addition to work induction, also in-house training and vocational education by local education partners will be provided.
    - The holistic induction plan will pay attention to not only operators learning the new skills, but also to them becoming part of the organization and integrated to the company culture.

Investment timeline and next steps

- To secure capacity 2025 onwards, discussions on LTAs and associated prepayment agreements are recommended to be started as early as possible.
- Construction of the fab expansion has started in Q1 2023.
- The fab expansion is in production use in 2025.
    - Evaluation samples available early 2025, after tool installations, acceptance and ramp-up.
    - Capacity ramp will be aligned to demand, full capacity by 2030.
    - Audits possible during 2025.

Actions needed from both parties to ensure smooth qualification process

Supply volume discussions and process change pre-notifications

Wafer specifications

Qualifications

POs

H1/23	• Supply volume potential discussed • Process change pre-notifications sent out
Q1/24	• Specification discussions
Q2/24	• Agreement on qualification plans: sample size and timeline
Q3/24	• Specifications finalized • Quotations • Purchase orders
Q1/25	• First qualification samples shipped out • Final PCNs sent out
Q3/25	• Customers accept PCNs • Productions POs • First production orders shipped out

Other current topics

COVID-19 hasn’t affected business continuity

- COVID-19 infections follow seasonal fluctuations with highs and lows
- 88% of Finnish population over 18 have received two vaccinations and 66% three vaccinations
- Pandemic hasn’t had major effects on Okmetic operations
  - Production has been up and running all the time
  - There have been some effects on availability of spare parts and materials, actions have been taken to ensure supply
  - Due to lockdowns, logistics in Asia somewhat affected, Okmetic following carefully and looking for alternative routings
- Installation proceeding well, travel is now close to normal
- BCP actions reviewed in all functions

Business continuity and supply chain risks related to Ukraine - Russia war

- The Ukraine-Russia war has raised questions of business continuity and supply chain risks.
- As an EU Member state and NATO member Finland can be considered as low-risk country despite close proximity to Russia.
- The prices of electricity and thermal energy have risen in Finland.
- Finnish energy companies and Okmetic have prepared for possible disruptions in electricity supply, but at the moment the risk for any disruptions is very low.
- Okmetic does no sourcing from Ukraine, Russia or Belarus.
- Air cargo to Asia is rerouted after flights in Russian airspace have been suspended.

Vantaa 150mm SSP polishing line renewal proceeding according to plans

- The renewal of 150 mm polishing line will take time and additional capacity is to be expected in H2 of 2023
    - First new tools were installed during 2Q22. First tools are supporting DSP and SOI products.
    - The last new tools will be installed in 2-4Q 2023.
- After polishing line renewal, the 150mm SSP line will primarily be reserved for SOI substrates, thick wafers, Engineered High Resistivity wafers etc.
    - Majority of standard material currently supplied from Vantaa 150mm SSP line have been qualified primarily to Okmetic subcontracting lines .
    - Expansion of subcontractor usage will continue and SubC evaluation is highly recommended.

Okmetic is actively participating in semiconductor industry events

Event	Date	Location	Information
Semicon West	July 11-13	San Francisco, CA	Senior Customer Support Manager Petri Santala will be giving a speech on “Latest development in silicon substrates for RF devices”.
Semicon Taiwan	Sep 6-8	Taipei, Taiwan	Attending
Power Semiconductor Executive summit	Sep 14-15	Stresa, Italy	Sponsoring, CTO Dr. Atte Haapalinna will be giving a speech on Customized Silicon and SOI Wafers Enabling Enhanced Power Devices.
MEMS & Imaging Sensors	Sep 19-21	Grenoble, France	Sponsoring
MSEC	Nov 6-8	Phoenix, AZ	Attending
Microfab Summit Virtual	Nov 7-9	Virtual	Customer Support Manager Akiko Gädda will be giving a speech on “Bonded SOI and Cavity SOI wafers Enabling Enhanced MEMS Designs”.
Semicon Europa	Nov 14-17	Munich, Germany	Booth under Silicon Saxony umbrella booth.

Semiconductor supply chain encounters cost increases

- Changes in global economics, geopolitical situation, high inflation rate and tight logistics are main reasons for semiconductor materials' cost increases

- Prices of production materials like polysilicon, chemicals, cassettes, polishing pads etc. have continuously increased in past 3 years.

- Cost of water, electricity and logistics have increased significantly in the past years.

- Increases and uncertainties are expected to continue in 2023, most likely even longer.

- Continued focus on supply chain risk management and planning for the unexpected

Mars exploration enabled with Murata Finland's sensor built on Okmetic's silicon wafer

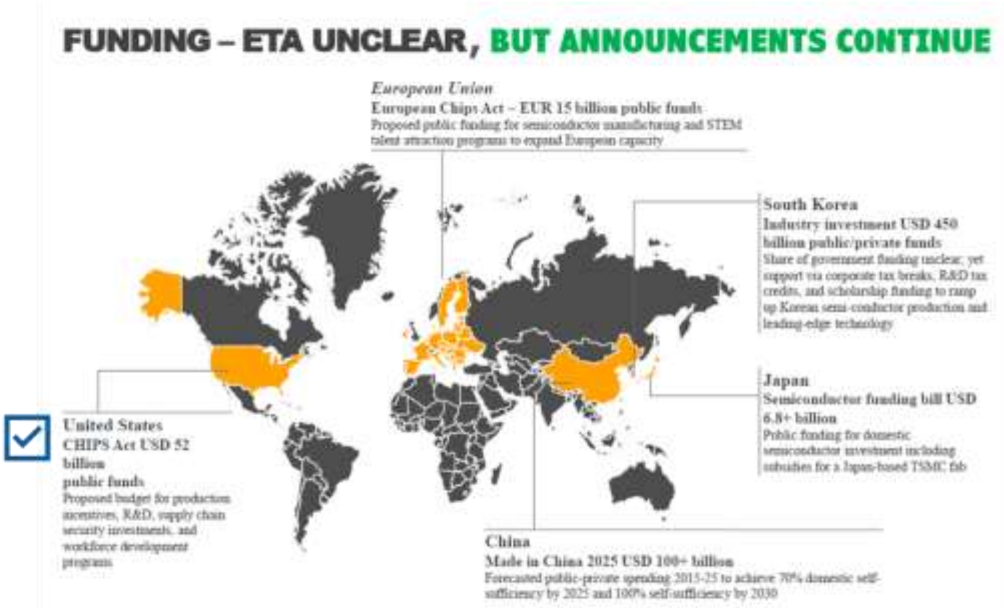
- NASA's Mars exploration is enabled with state-of-the-art sensor technology by Murata Finland using Okmetic's advanced silicon wafer as a platform
- Murata Finland's SCA100T dual-axis inclinometer is used in NASA's Ingenuity helicopter, which arrived on Mars with the Perseverance rover in February 2021
- The purpose of the inclinometer is to eliminate the inclination errors of the separate IMU through calibration before each flight to ensure trip accuracy
- The signal produced by the sensor must be extremely precise because on Mars, the inclination signal is about one-third of that measured on Earth

Market update

- Revenue, growth drivers and shipments
- Semiconductor CAPEX and WFE
- Fab capacity outlook, 200 mm

Semiconductors Revenue outlook

Massive stimulus funding in the works



FUNDING – ETA UNCLEAR, BUT ANNOUNCEMENTS CONTINUE

European Union
European Chips Act – EUR 15 billion public funds
Proposed public funding for semiconductor manufacturing and STEM talent attraction programs to expand European capacity

South Korea
Industry investment USD 450 billion public/private funds
Share of government funding unclear; yet support via corporate tax breaks, R&D tax credits, and scholarship funding to ramp up Korean semi-conductor production and leading-edge technology

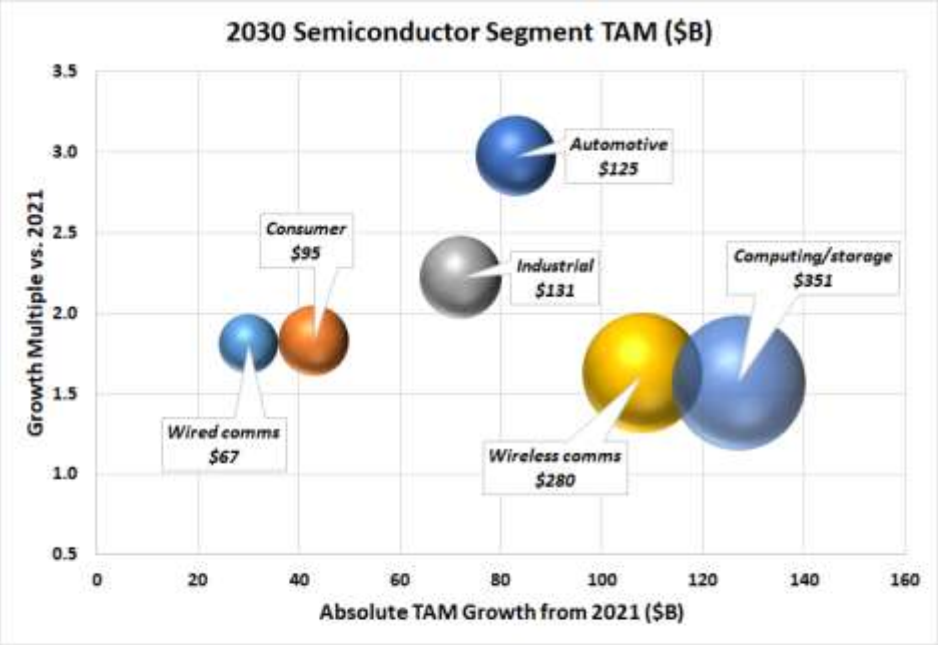
Japan
Semiconductor funding bill USD 6.8+ billion
Public funding for domestic semiconductor investment including subsidies for a Japan-based TSMC fab

☑ **United States**
CHIPS Act USD 52 billion public funds
Proposed budget for production incentives, R&D, supply chain security investments, and workforce development programs

China
Made in China 2025 USD 100+ billion
Forecasted public-private spending 2015-25 to achieve 70% domestic self-sufficiency by 2025 and 100% self-sufficiency by 2030

- Semiconductors and related components continue to be a focal point for public policy
- National and local governments are joining forces in funding expansions
- Numerous company announcements have been made in multiple countries and more are expected

Semiconductor market in 2030 (McKinsey)



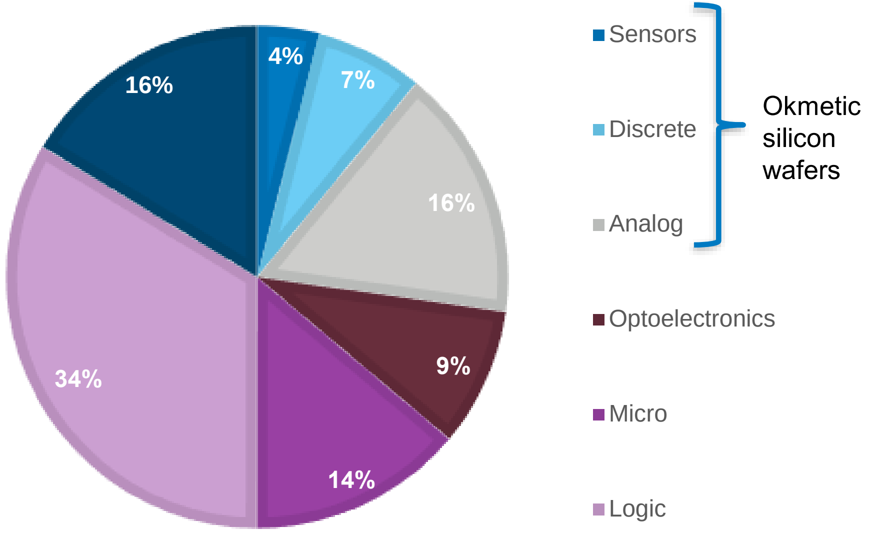
Source: McKinsey, Okmetic Market Intelligence

- The global semiconductor market is prone to strong secular growth, despite cycles
- The total market value is expected to exceed $1T by 2030
- The most rapidly expanding semiconductor TAM segments are automotive and industrial - those are expected to increase 3x and 2.2x their respective 2021 levels by 2030

Semiconductors By device type (WSTS)

Semiconductor market forecast at 515BUSD in 2023

Market size forecast 515BUSD in 2023



Source: WSTS, May 2023

- Semiconductor market value is expected to decline by -10,3% in 2023
  - Analog -5.7%
  - Sensors -6.3%
  - Discrete +5.6%
- Europe is forecast to show 6.3% and Japan 1.2% growth, while Americas and APAC are expected to decline by -9.1% and -15.1% respectively.
- Robust recovery 11.8 percent is estimated for 2024.

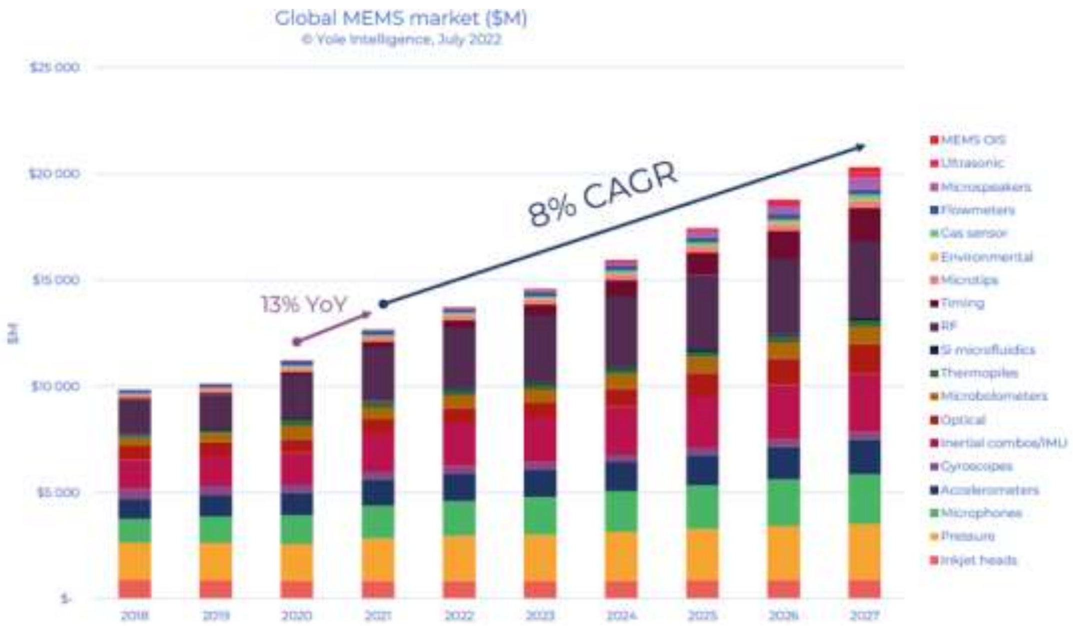
Semiconductor market value 515BUSD

Spring 2023	Amounts in US$M			Year on Year Growth in %		
	2022	2023	2024	2022	2023	2024
Americas	141,136	**128,236**	**150,989**	16.2	-9.1	17.7
Europe	53,853	**57,253**	**61,637**	12.8	6.3	7.7
Japan	48,158	**48,724**	**52,534**	10.2	1.2	7.8
Asia Pacific	330,937	**280,881**	**310,838**	-3.5	-15.1	10.7
Total World - $M	574,084	**515,095**	**575,997**	3.3	-10.3	11.8
Discrete Semiconductors	33,993	**35,904**	**38,192**	12.0	5.6	6.4
Optoelectronics	43,908	**45,949**	**45,881**	1.2	4.6	-0.1
Sensors	21,782	**20,410**	**21,575**	13.7	-6.3	5.7
Integrated Circuits	474,402	**412,832**	**470,349**	2.5	-13.0	13.9
Analog	88,983	83,907	88,902	20.1	-5.7	6.0
Micro	79,073	71,470	75,855	-1.4	-9.6	6.1
Logic	176,578	173,413	185,266	14.0	-1.8	6.8
Memory	129,767	84,041	120,326	-15.6	-35.2	43.2
Total Products - $M	574,084	**515,095**	**575,997**	3.3	-10.3	11.8

Source: WSTS, May 2023

A closer look at MEMS Market and ecosystem (Yole)

MEMS expanding in applications and sales



Source: Yole Intelligence

- Although maturing, the MEMS market is forecast to show continued solid growth
- Sales are expected to move from $13.5B today to more than $20B within 5 years

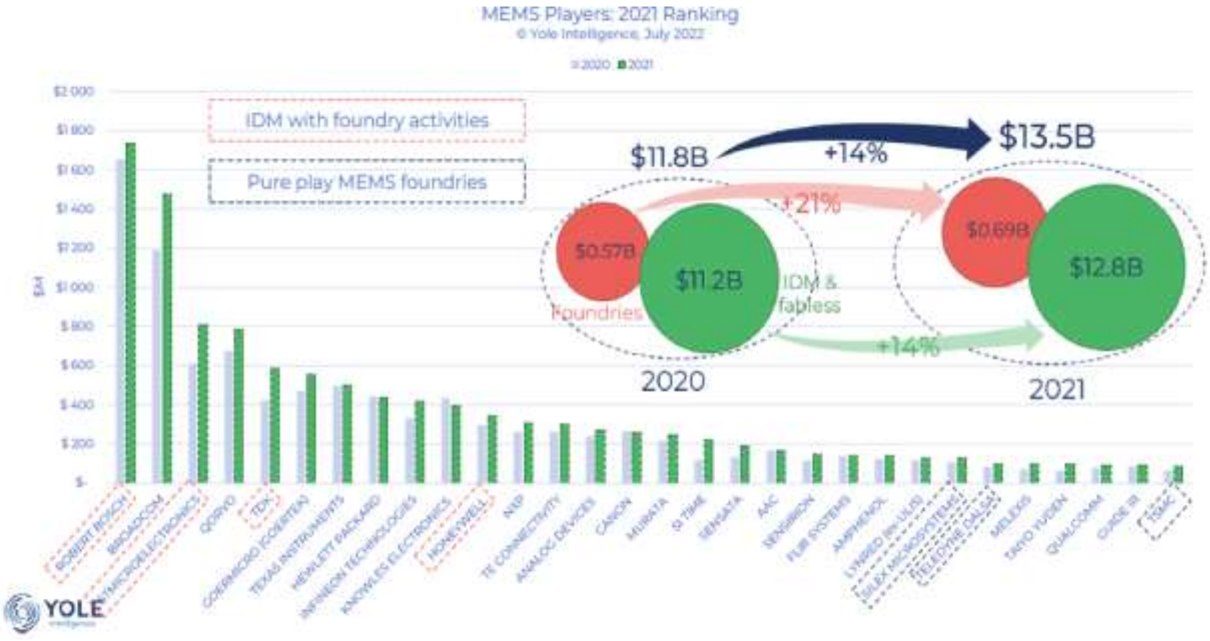
Both old & new faces are driving the market

Percentage values represent ‘21 – ’27 CAGR

Source: Yole Intelligence

- Growth is expected in both secular and emerging applications across key markets
- Familiar devices continue to expand on their established bases while new solutions show significant development

IDM and pure play foundries grew in 2021

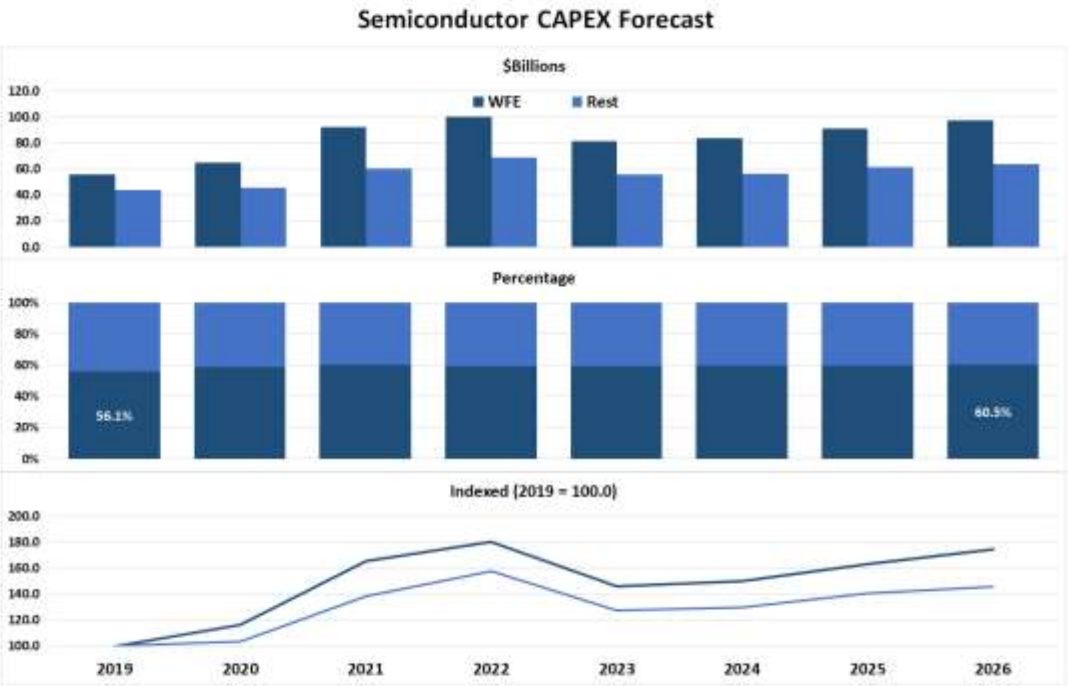


Source: Yole Intelligence

- Most of the top-10 showed YoY growth
- IDM & fabless continued to account for >90% share
- But foundries share increased by 30bps and showed higher relative gains overall (+21.1% vs. +14.3%)

Semiconductor CAPEX and WFE

Semiconductor CAPEX dips, remains strong

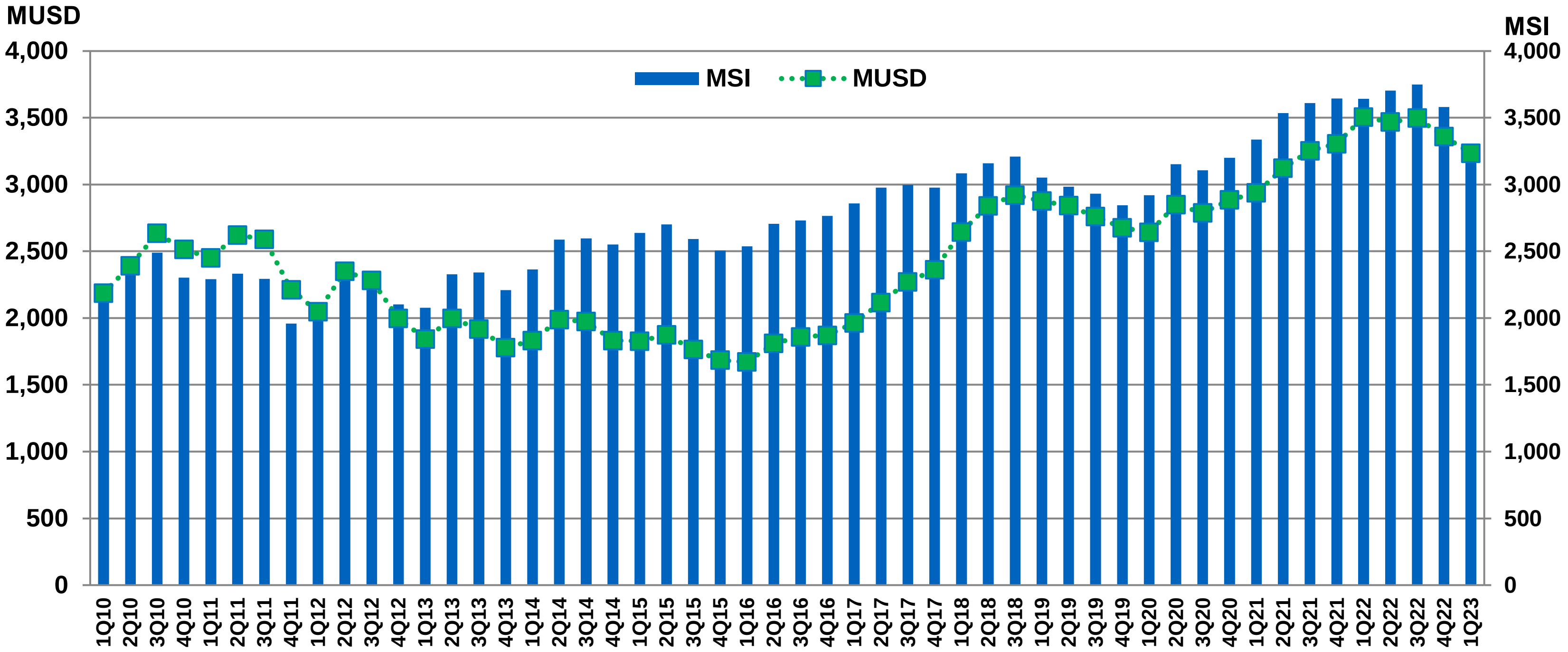


Source: Gartner, Okmetic Market Intelligence WFE = Wafer Fab Equipment

- After reaching a record of >$100B in 2022, WFE is expected to decline in 2023 but show growth sequentially through 2026
- By 2026, WFE is expected to represent more than 60% of the CAPEX spend
- Even with the correction in 2023, WFE is up >40% versus 2019

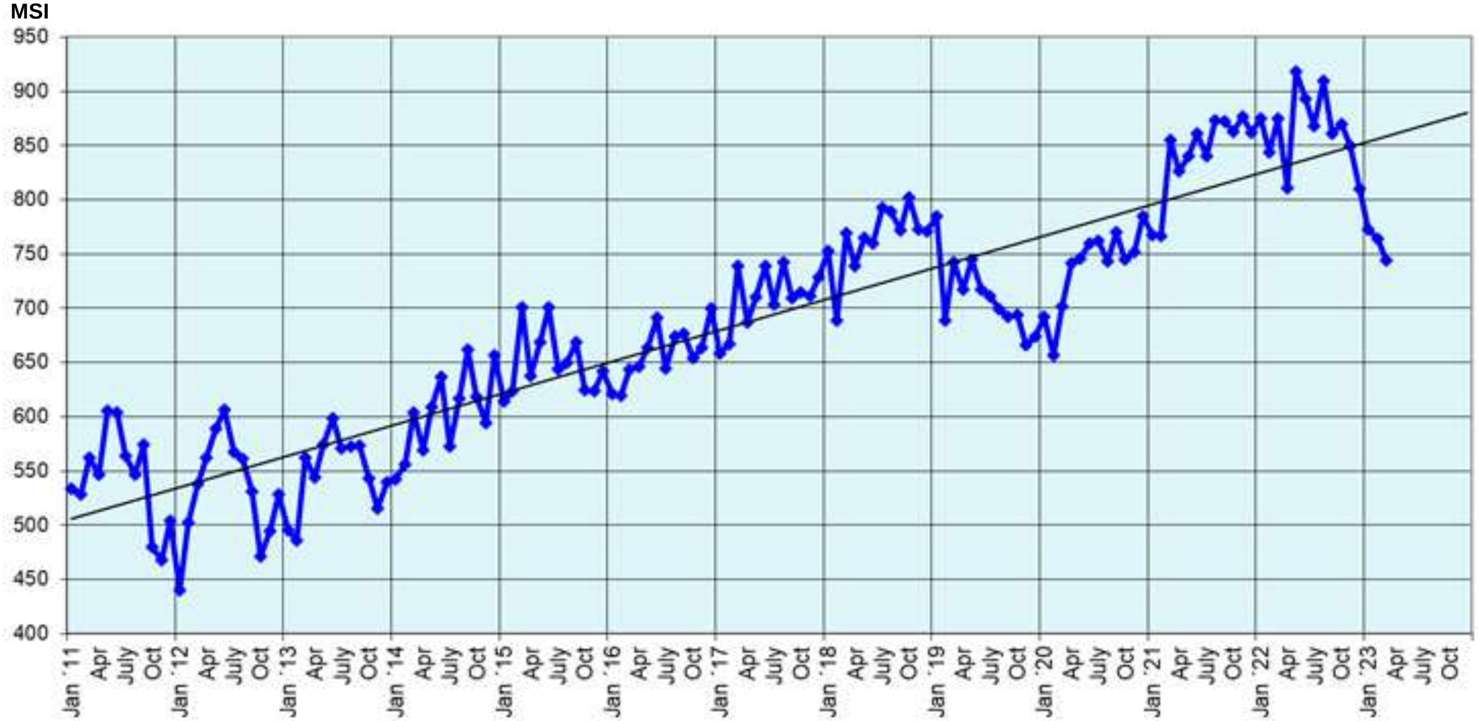
Materials (SEMI)

Wafer shipments & sales show softening (SEMI)



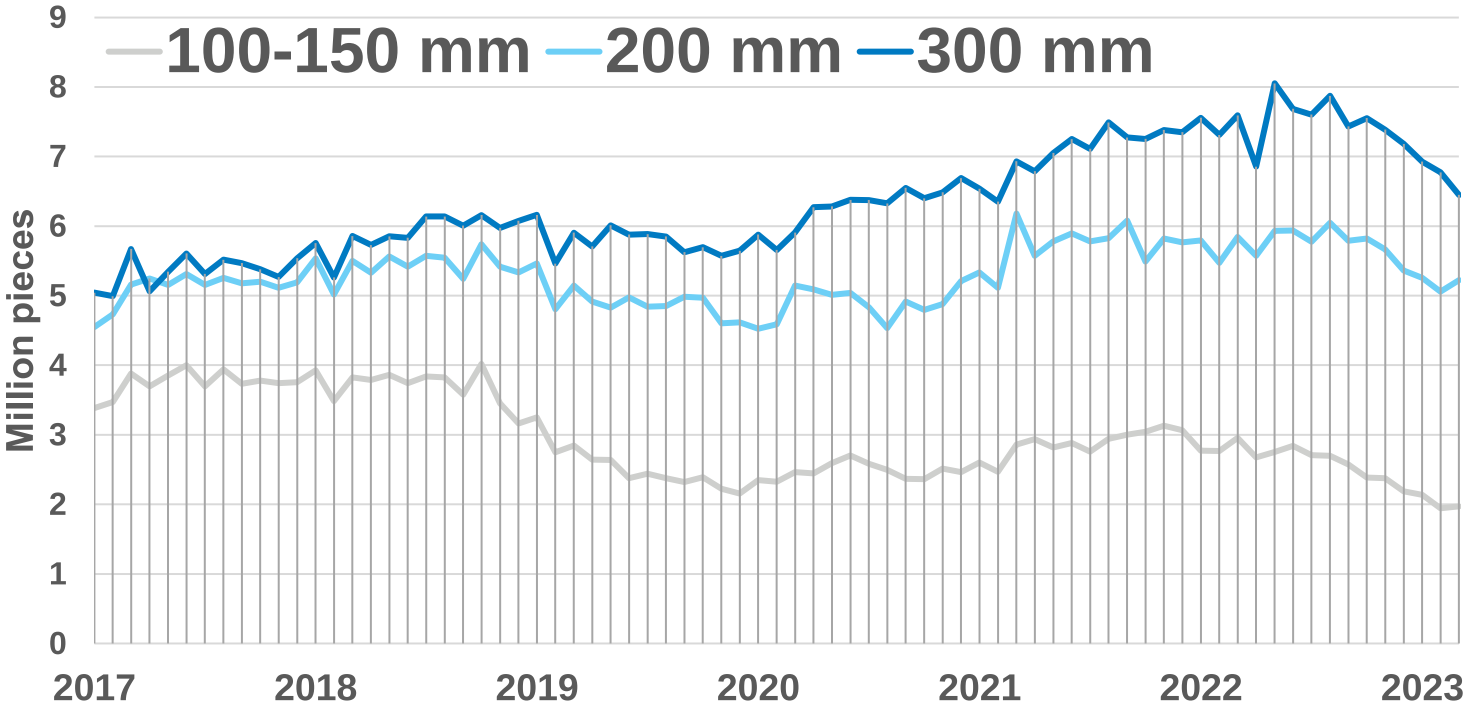
OKMETIC

Monthly polished silicon shipments (SEMI)



OKMETIC

Unit shipments - Monthly WW wafer shipments (SEMI)



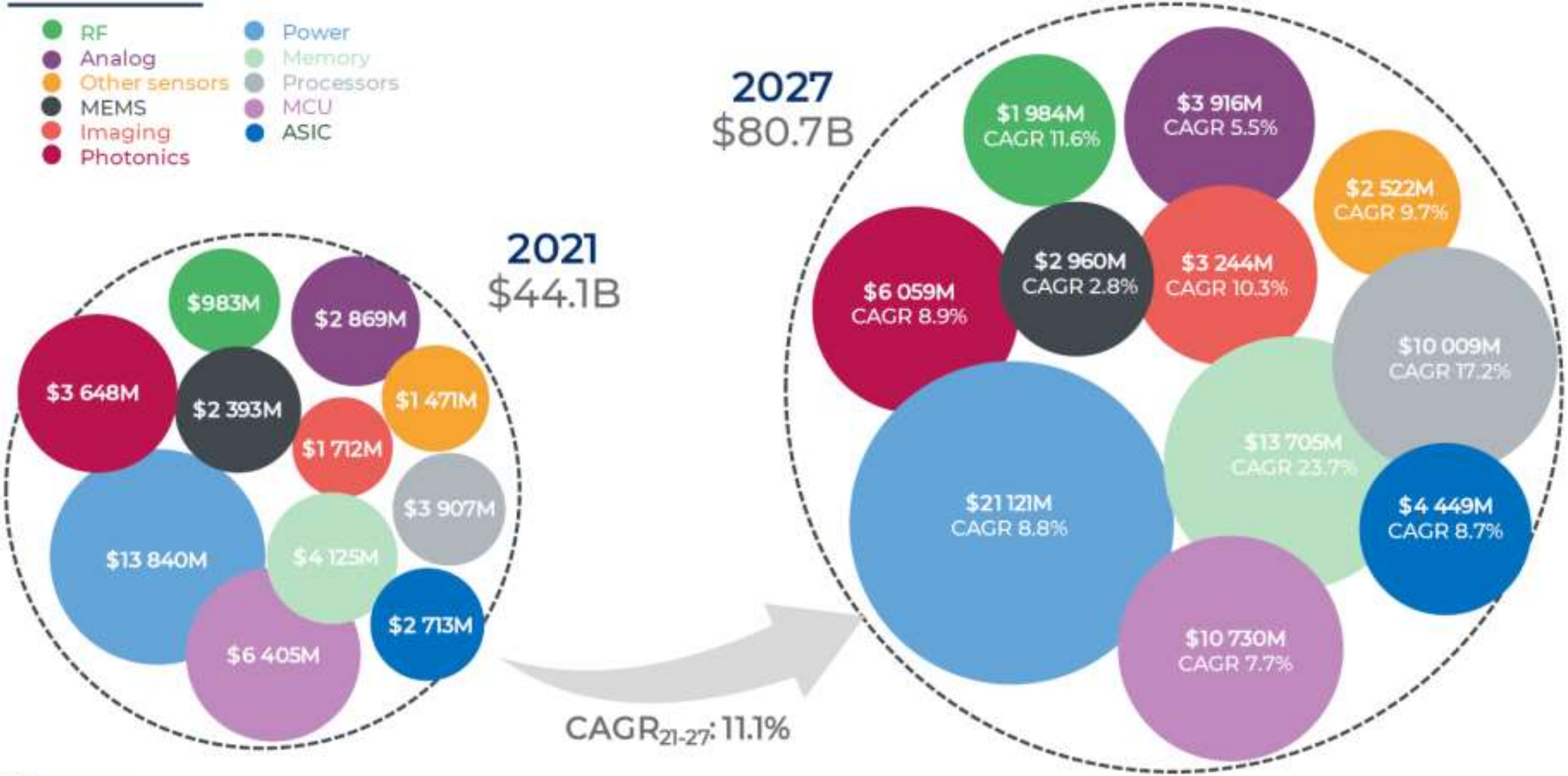
300 mm
~6.5 M pcs/m

200 mm
~5 M pcs/m

100-150 mm
~2 M pcs/m

Fab Capacity, ≤200mm (SEMI)

2021-27 SEMICONDUCTOR AUTOMOTIVE APPLICATIONS



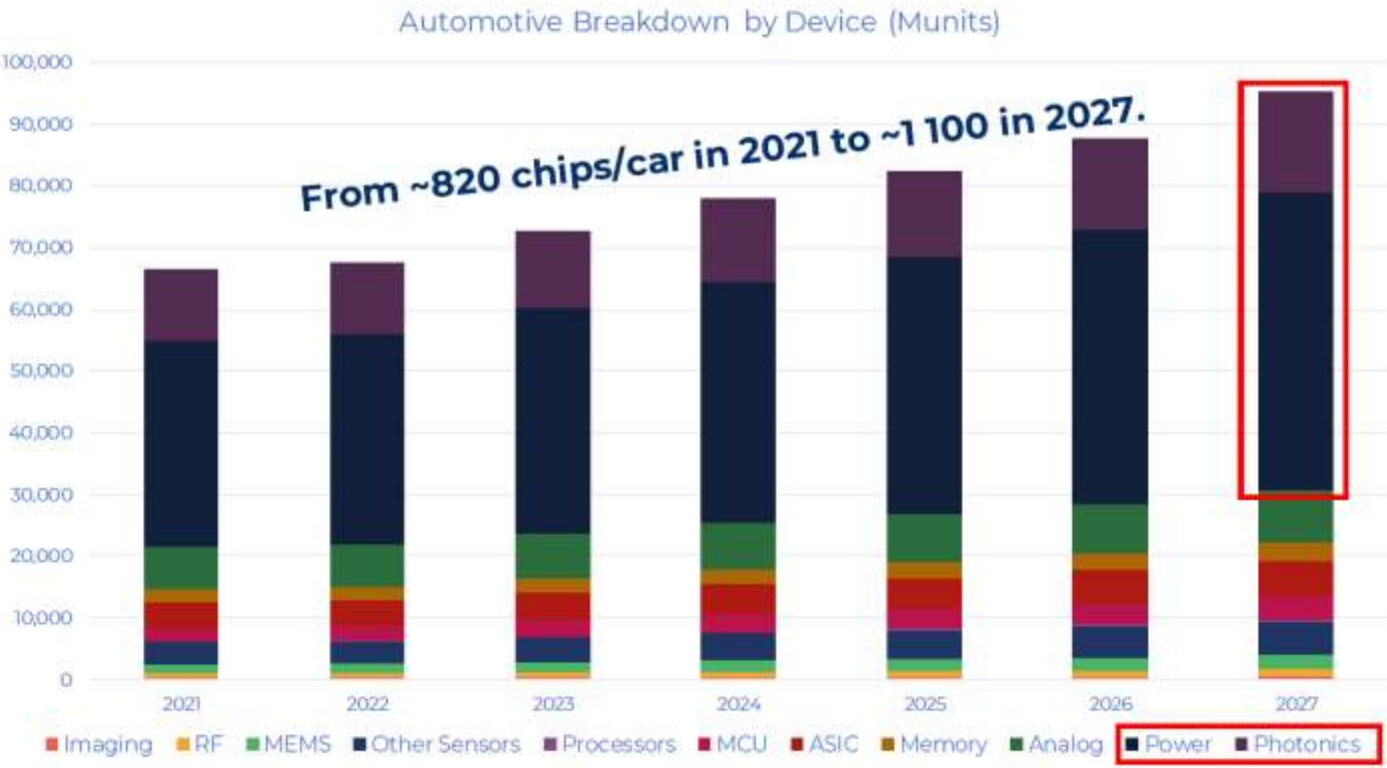
SEMICONDUCTOR SHIPMENTS (UNITS) FOR AUTOMOTIVE

In 2027, over 95 billion chips will be integrated in cars.

Power & Photonics dominate, Memory & Processors highest growth rate.

In 2021, the total shipment volume of all semiconductor chips was estimated to be 1T units.

Automotive applications accounted for 7% (units).

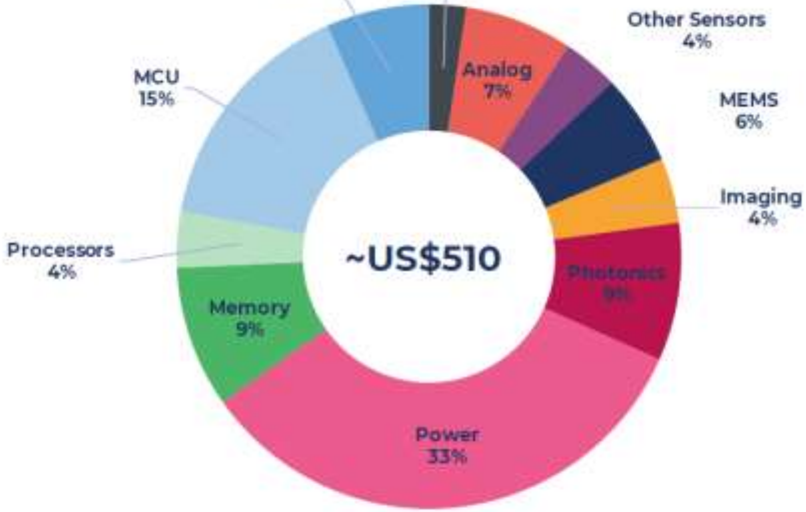


YOLE Intelligence

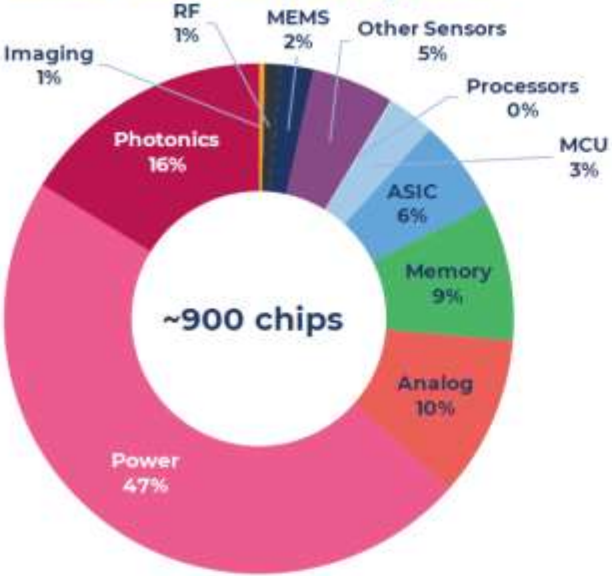
CONTENT PER CAR

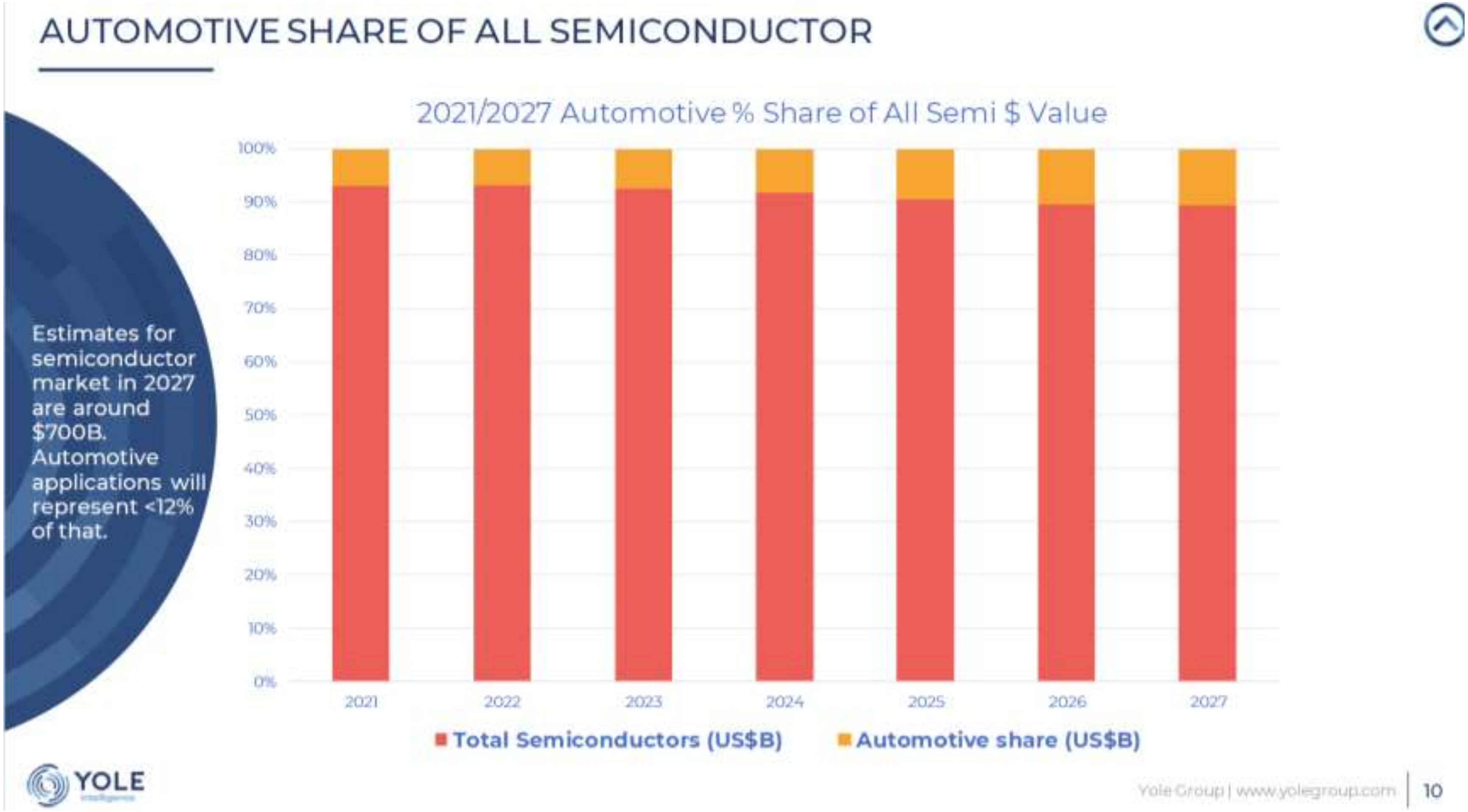
Average content of chips per car by revenue and volume in 2021.
Power devices account for a large share in both value and volume.

2021 semiconductor content $ share



....and volume (units) share





AUTOMOTIVE SHARE OF ALL SEMICONDUCTOR

Estimates for semiconductor market in 2027 are around $700B. Automotive applications will represent <12% of that.

2021/2027 Automotive % Share of All Semi $ Value

Other Considerations

- 1Q CY2023 sales forecasted to decline across the industry (chips, materials and equipment)
- Tech Industry has announced layoffs, more likely
- Push out of some expansion projects
- However,
- Conversations reinforce expectation of improving industry conditions in 2H 2023
- Infineon to begin work on €5 B chip plant in Germany
- Texas Instruments for US$11 B expansion in Lehi
- TSMC to boost capital at Arizona factory by US$3.5 B
- Wolfspeed to Build 200-mm SiC Wafer Fab in Germany
- Samsung working diligently to complete Taylor facility

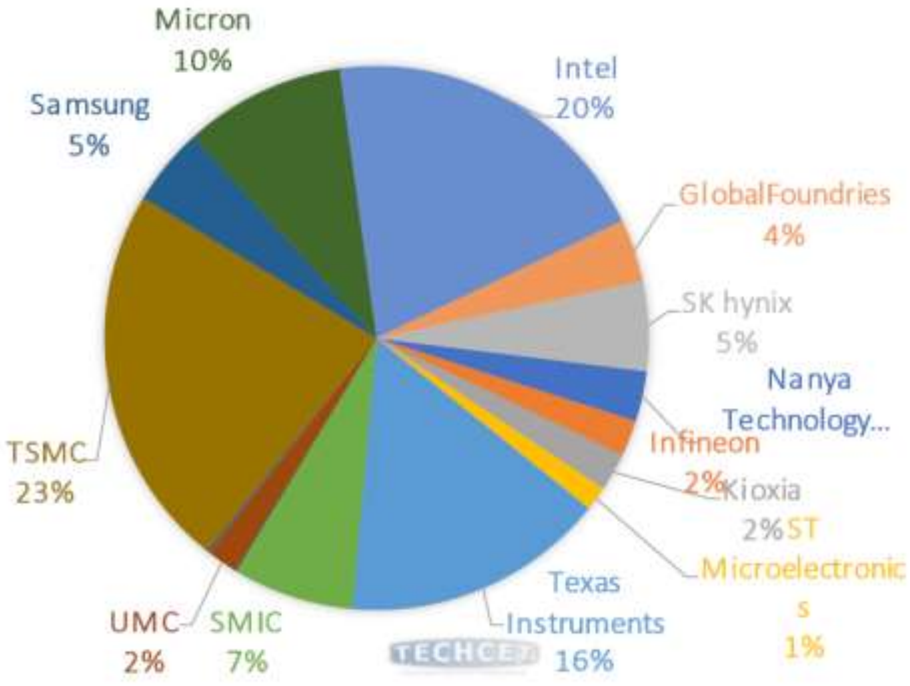
Company	Q1 Revenue Growth
ASE	-16%
Amkor	-24%
AMAT	-5%
ASML	-2%
Entegris	-5%
Infineon	-3%
Intel	-21%
Lam Research	-21%
Micron	-7%
Sumco	-12%
TSMC	-14%

Source: TECHCET

Industry Status and Expansion

- US$366 B of investments 2022-2027
- Added growth possible but in jeopardy from materials limitations
- Demand driving huge growth in already strained materials supply-chains

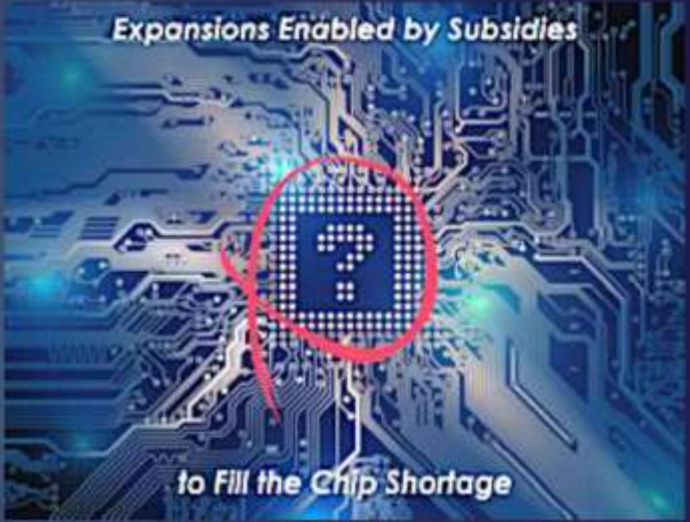
2022-2027 WORLDWIDE FAB EXPANSION ($366B)



TECHCET

WW Fab Expansion Driving Growth

- Government initiatives and subsidies contributing to the expansion (over 5 years)
  - US Chips Act $52B - approved
  - EU Chips Act - 43B Euros - proposed
  - Korea Chips Act – financial, regulatory, and tax incentives totaling 340 T Won (~US$259B)
  - China – US$1.4T pledged for over 5-10 years*
  - Taiwan – $260M USD in 2020 + ~$53M USD WFD
  - Japan - $2.8B; up to $^{1}/_{3}$ for chips (power, controllers, analog); up to ½ for raw materials



- **This demand is driving huge growth in materials, will continue the strain on supply-chains**

$186B US Investments for New Fabs Sparked by $52B CHIPS Act

- GlobalFoundries: Malta (New York)
- Intel: Chandler (Arizona), Columbus (Ohio)
- Micron: Boise (Idaho) Syracuse (NY)
- Samsung: Taylor (Texas)
- Skywater: Lafayette (Indiana)
- Texas Instruments: Sherman (Texas), Lehi (Idaho)
- TSMC: Phoenix (Arizona)
- And planned expansions of pre-existing fabs

US Chip Expansions 2022-2027

Okmetic is part of the NSIG group

Okmetic is part of Chinese NSIG since 2016

NSIG

Crystal and prime wafer production

OKMETIC

150-200 mm wafers incl. SOI

ZINGSEMI

300 mm wafers

Epi and smart cut processes

SIMGUI

150-200 mm wafers

soitec

200-300 mm wafers

NSIG owns 10-12% of shares

National Silicon Industry Group (NSIG) is a China-based holding group engaged in the investment and development of semiconductor materials and equipment industry. NSIG is listed on the SSE STAR market, China’s new Nasdaq-style tech board.