GlobalWafers Co., Ltd.
環球晶圓股份有限公司

Global Family, Global Solutions!

NTD SILICON - ENABLING THE WORLD OF TOMORROW

A Market Outlook - Time of Oppertunity

IGORR 22nd & IAEA TM

15 - 19 June, Mito, Japan

TOPSIL

Martin Græsvænge
Quality & NTD Manager

Topsil at a glance

- July 2016 Topsil GlobalWafers A/S established, becoming the Float-Zone site of GlobalWafers Co. Ltd., Taiwan
- Long company history – FZ silicon production since 1959
  Long term customer relations
- Current site near Copenhagen - state of the art fab, opened 2012
- Agile organization - Short decision-making processes
- Close cooperation with universities and research institutions worldwide

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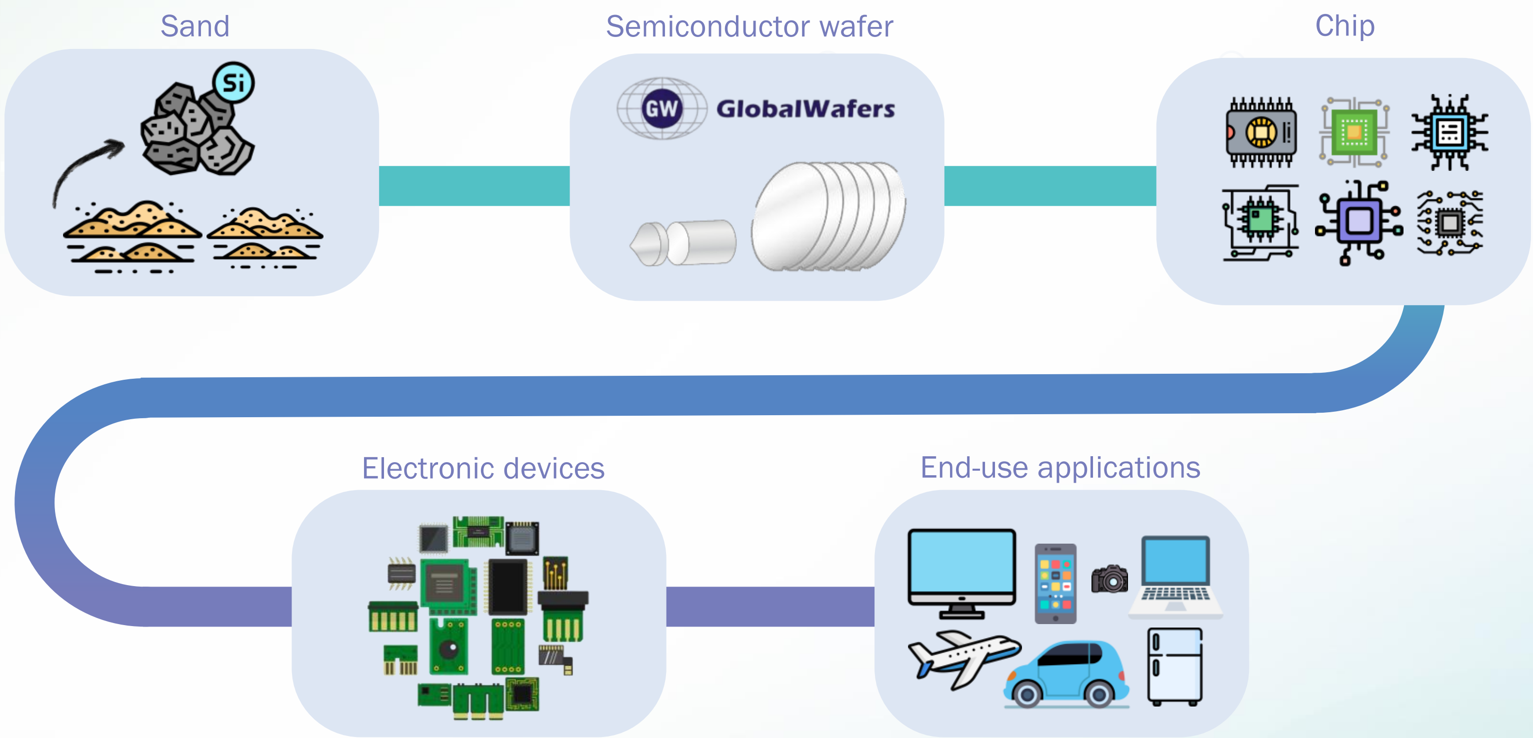
The Journey of Semiconductors: From Sand to Chip

The journey of semiconductors, from sand to chip, transforms silicon into the core of modern technology. Embedded in everyday products, semiconductors drive innovation and functionality, shaping the way we live and work.



The Invention of NTD Silicon

Karl Lark-Horovitz:

$^{30}\mathrm{Si}(n,\ )\ ^{31}\mathrm{Si} > {}^{31}\mathrm{P} + \beta^{-}$ (2.6 h)
$^{28}\mathrm{Si}(n,\ )\ ^{29}\mathrm{Si}$
$^{29}\mathrm{Si}(n,\ )\ ^{30}\mathrm{Si}$
$^{31}\mathrm{P}(n,\ )\ ^{32}\mathrm{P} > {}^{32}\mathrm{S} + \beta^{-}$ (14.3 h)

1951

1950s

Dr. Haldor Topsøe initiates Float Zone tests, Denmark

1959

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1974

Topsil contacts RISOE National Laboratory on possibility of neutron irradiation of silicon

Mid 1970s

Topsil pioneers industrial manufacture of NTD together with RISOE

1980

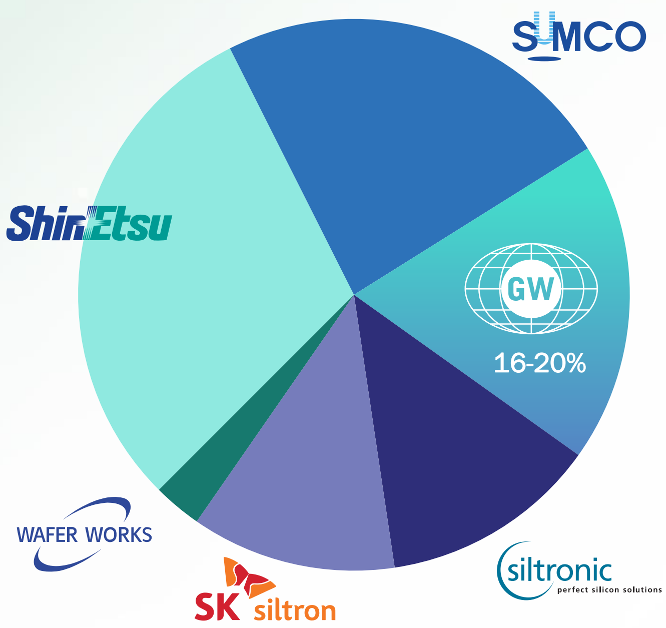
High and medium power thyristors and power transistors are based on NTD Si.
Several suppliers of NTD Si and irradiation

The Journey of Semiconductors: From Sand to Chip

From polysilicon refining to crystal growth and wafer manufacturing, GlobalWafers meticulously crafts high-quality, precision-engineered semiconductor wafers that serve as the foundation for advanced electronic devices.

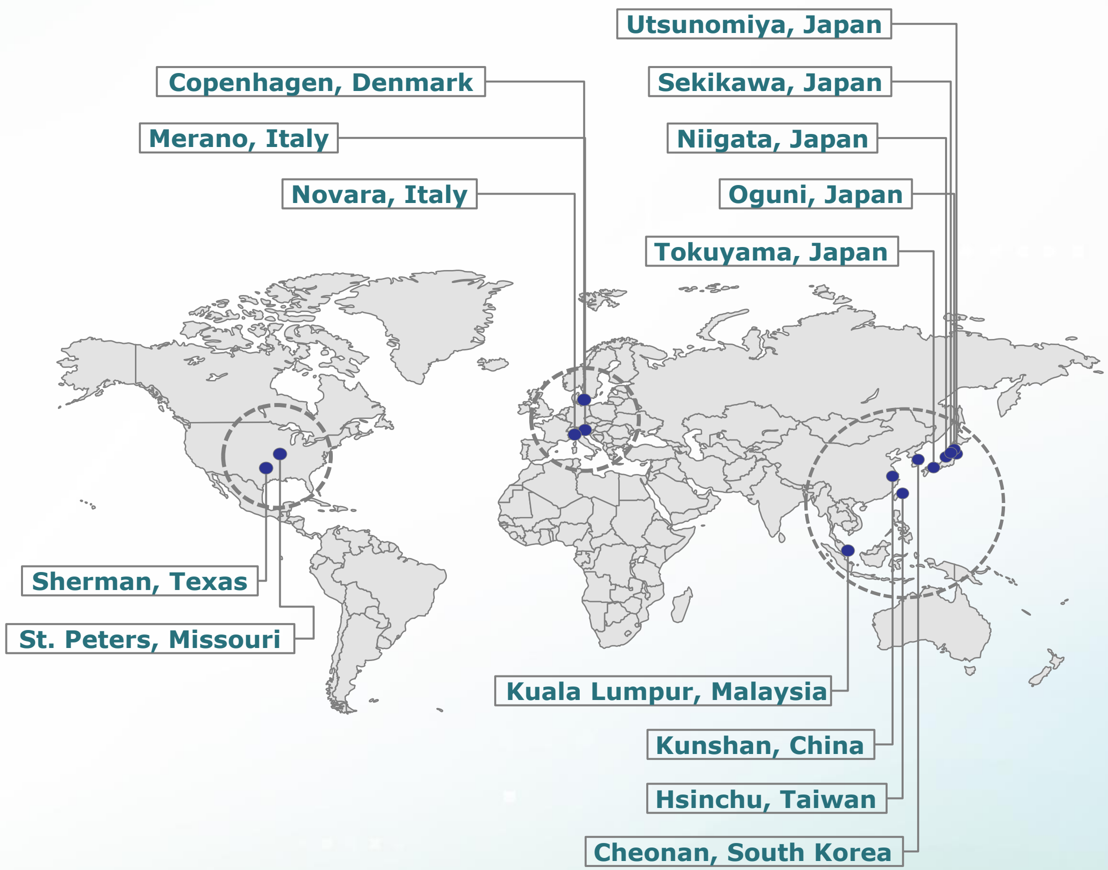
GlobalWafers and Other Wafer Manufactures

Top 6 wafer suppliers worldwide



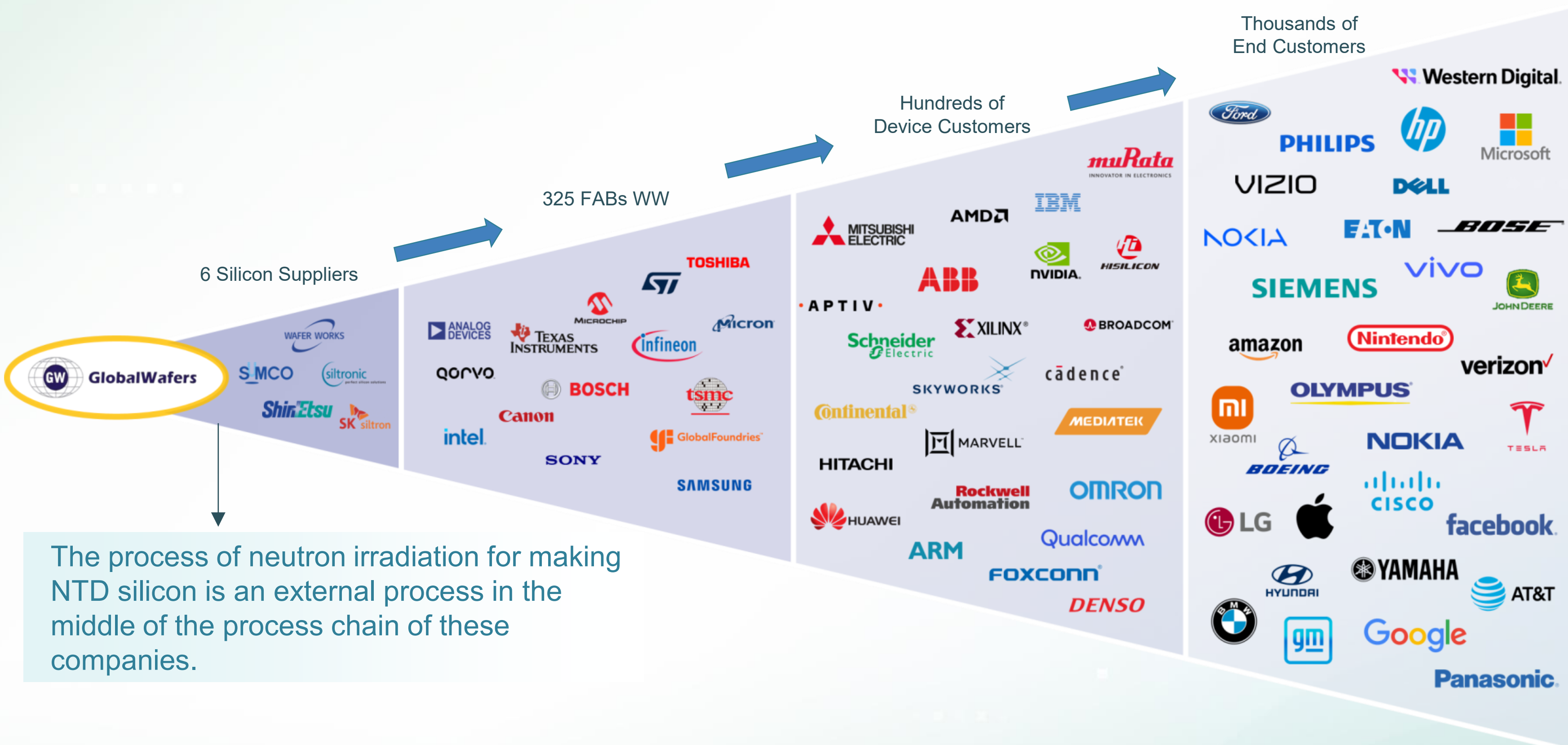
Source: Public company information.

GlobalWafers sites



GlobalWafers' Position in the Semiconductor Industry Chain

The semiconductor industry is one of the most complex industries globally, and its supply chain heavily relies on the top six wafer suppliers. As the third-largest silicon supplier, GlobalWafers provides essential high-quality semiconductor wafers, which are crucial substrates in semiconductor processes and support the development of advanced manufacturing technologies.



The process of neutron irradiation for making NTD silicon is an external process in the middle of the process chain of these companies.

Characteristics of NTD silicon: Low Resistivity Variation

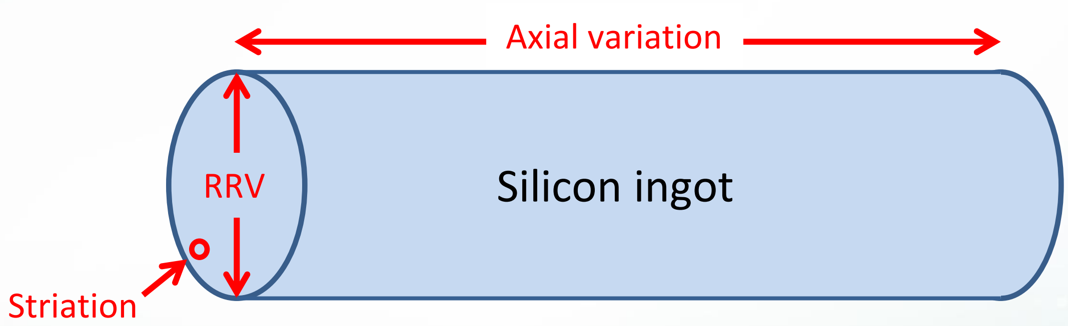
Resistivity uniformity is essential for the performance of many power components such as: thyristors, power diodes, rectifiers, and IGBTs.

Motivation for low resistivity variation

- Lower resistivity variation enable more e.g. IGBT components on the wafer which are more closely matched – economy of scale.
- Allow for assembly of devices in large complex systems
- Hot spots with break through are avoided.
- Large thyristor components are possible.

Resistivity Tolerance	**±5 %**
Radial Resistivity Variation	<5 %
Resistivity Striations	Not detectable
Axial Resistivity (batch)	**<4 %**

Resistivity variation:

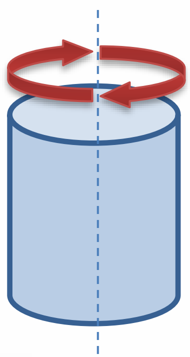


FZ: low axial variation
NTD: low RRV and striation

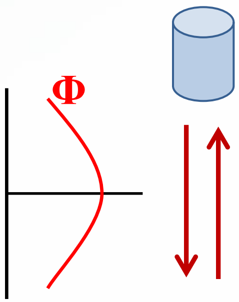
NTD Silicon – Uniformity Methods

Radial Uniformity

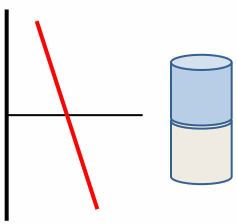
- Constant rotation of Si ingot to compensate for flux gradient in irradiation position
- Reduce effect of intrinsic neutron attenuation in the Si ingot
- Dummy material on top and bottom of irradiation batch



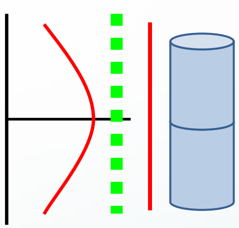
Axial Uniformity



Round Trip
Horizontal or Vertical
✓ All Si sees the same neutron profile
○ More space needed



Switching or Upside-down
✓ Limit space needed
✓ No extra installations
○ More handling
○ Two/four irradiations



Neutron Filter
✓ Maximize irradiation length
○ Reduced neutron flux
○ Fixed irradiation position

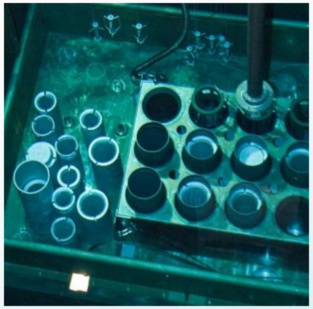
NTD Silicon - 2025

The typical silicon dimensions for today's commercial NTD silicon production is

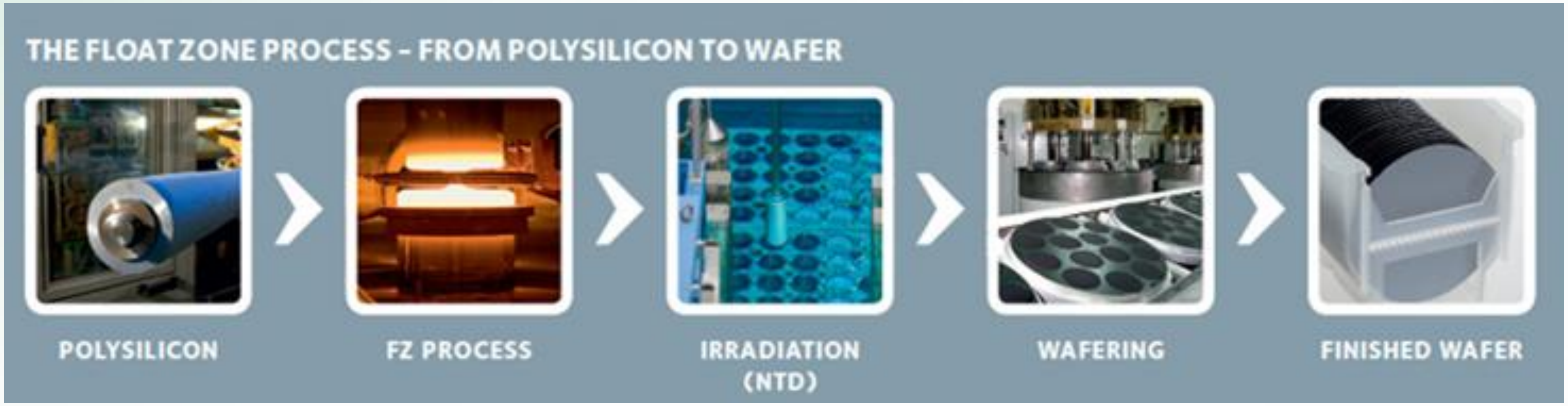
- Up to 203 mm in diameter in four categories:
  - 4″ (102-105 mm)
  - 5″ (125-129 mm)
  - 6″ (151-154 mm)
  - 8″ (201-204 mm)
- Single ingot length normally up to 300 mm (typical: 120-199, 200, 250 or 300 mm)
- Batch length normally up to 600 mm

Irradiation time normally ranges from 15 min to 8 hours of course depending on initial resistivity, target resistivity, and flux density (5E+11 to 4E+13 n/(cm2*s)).

	Required Fluence (E+17 n/cm^2)	Corresponding Resistivity (Ω·cm)
Typical targets for NTD silicon	0.2 – 2.6 (7.4)	1,200 – 100 (35)



The Value Chain of NTD



SILICON SUPPLIERS: DEPENDENT ON EXTERNALLY CONDUCTED IRRADIATION

Irradiation partners to deliver:

- Predictable capacity
- High yield – high doping accuracy
- An efficient manufacture
- Short lead time
- Maintain integrity of silicon; physically and chemically (avoid contact to metals)

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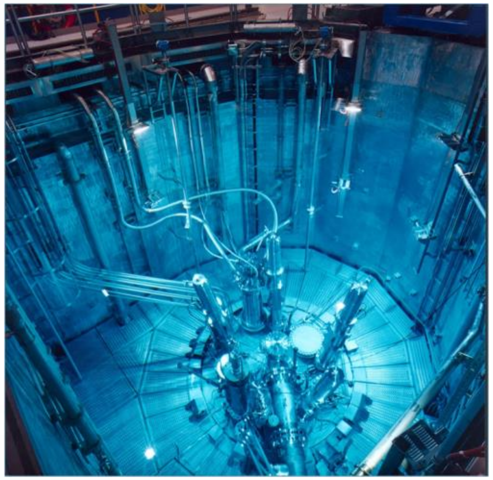
Structured for Top Quality

- Well established data management system
- Strict focus on meeting quality related goals throughout the production process
- Continuous improvements: Application of Lean tools and principles to improve performance and minimise waste



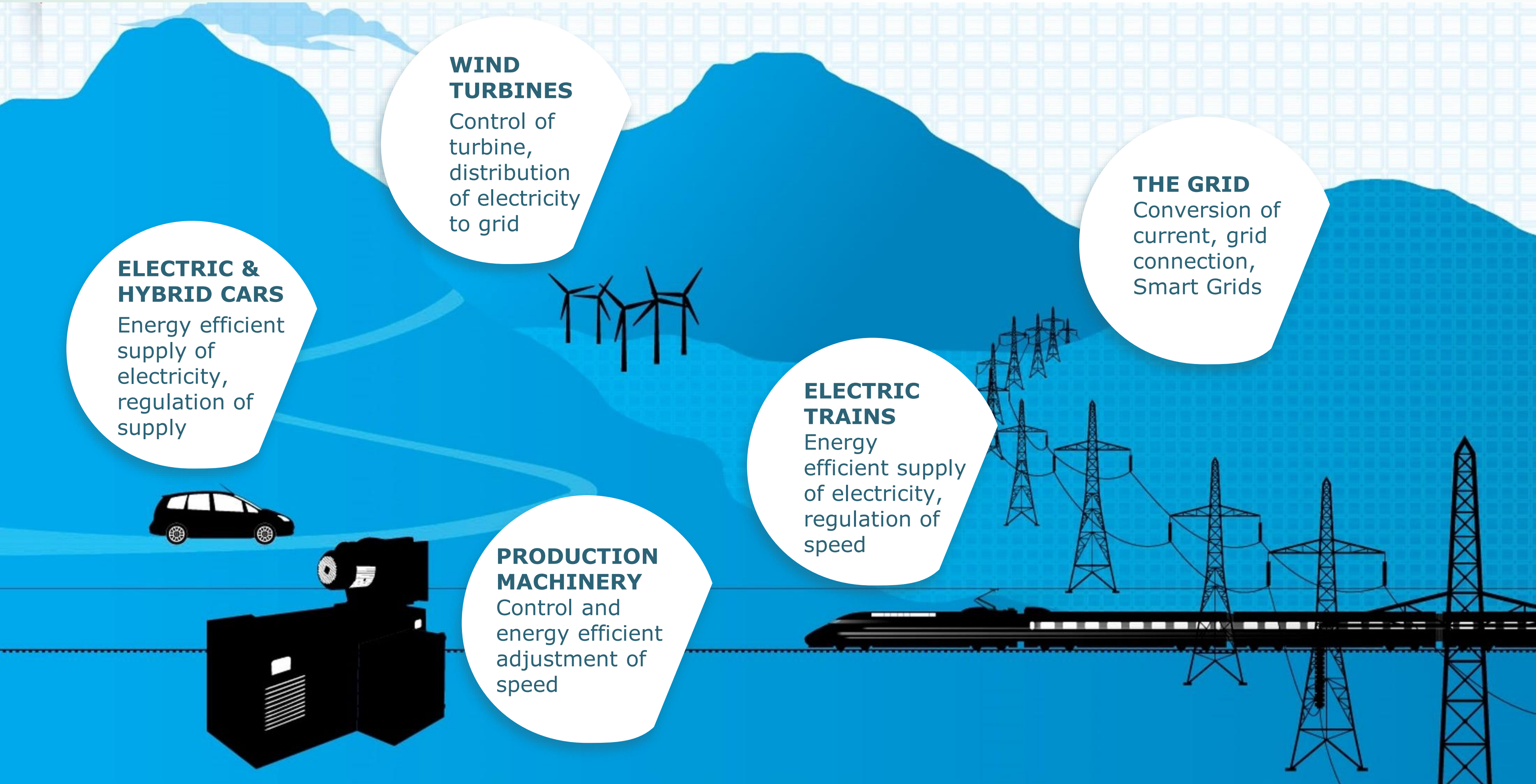
Picture: FRM-II, TUM, Germany

Requirement for irradiation site

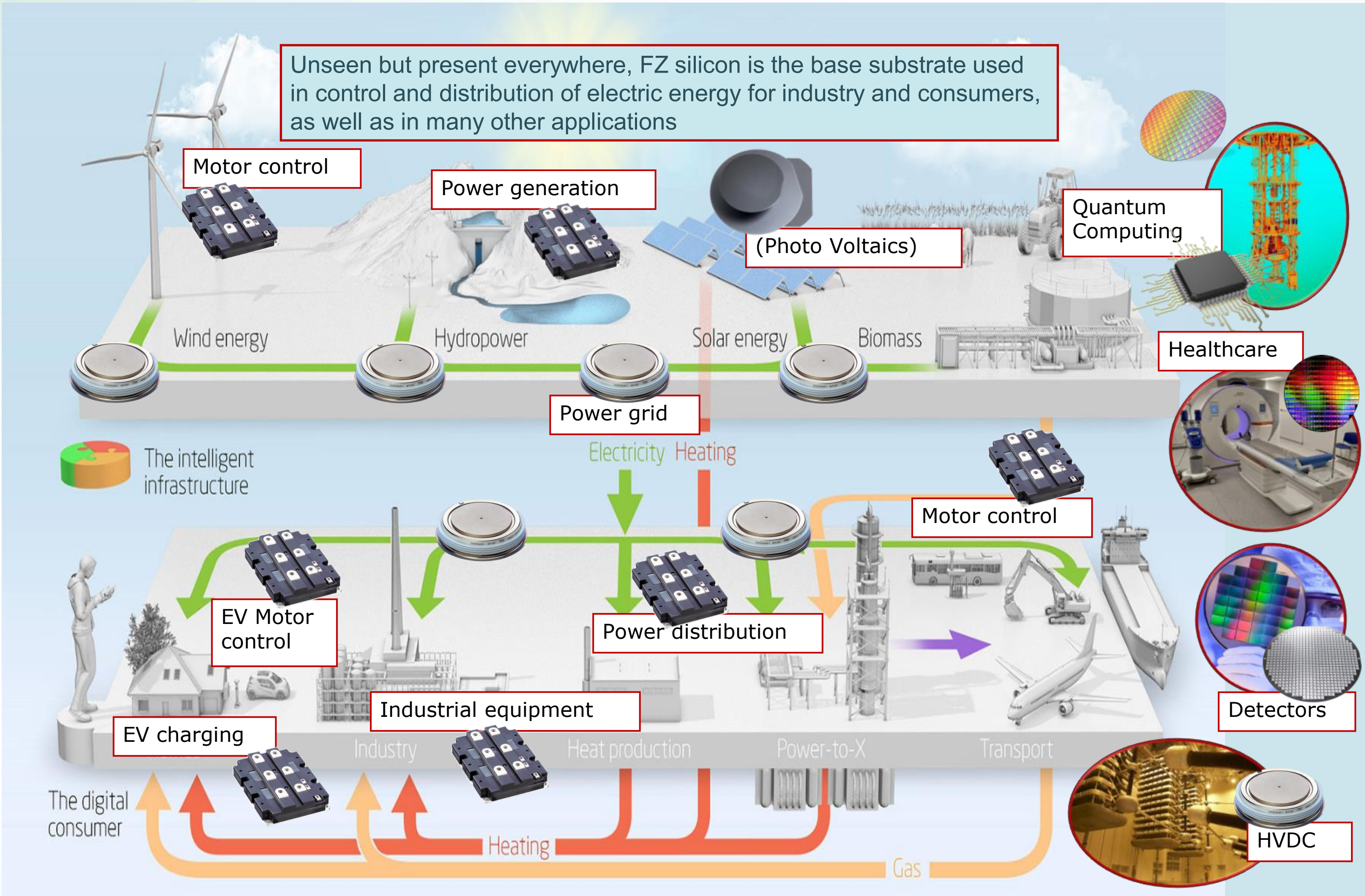
Certifications:

- IATF 16949 Automotive Level Management
- **ISO 9001 Quality Management**
- ISO 14001 Environment Management
- ISO 45001 Health and Safety Management
- ISO 50001 Energy Management
- ISO 14064 Greenhouse Gases

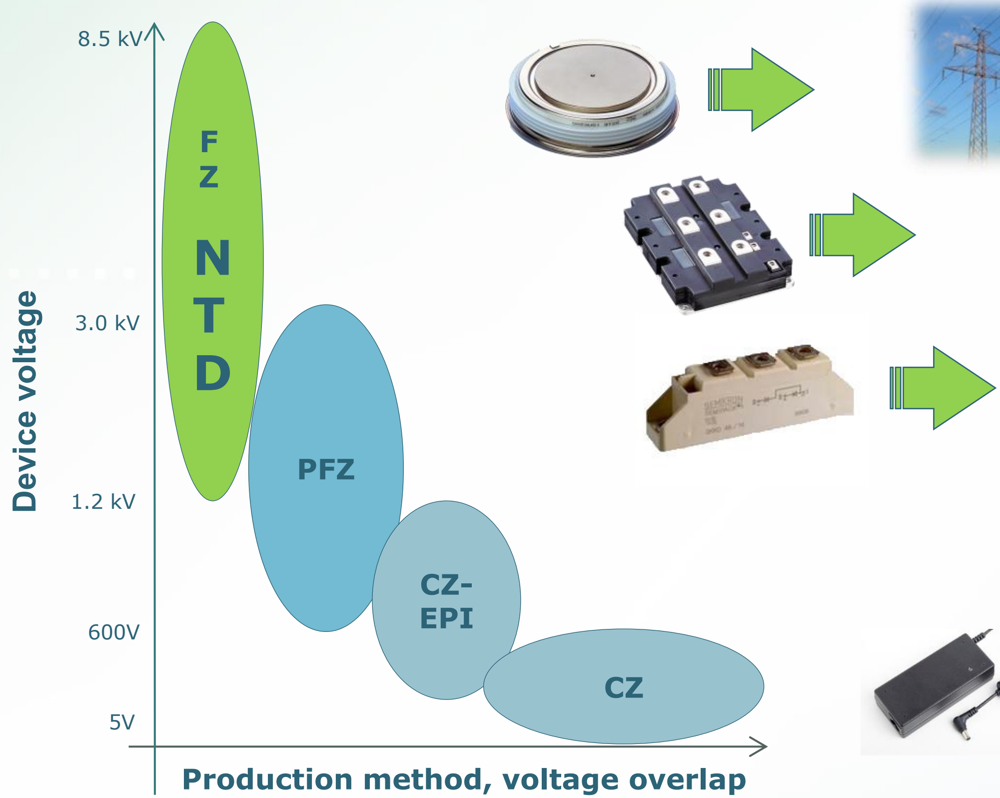
Ultrapure Float-Zone Silicon Enabling the World of Tomorrow



Where Float Zone silicon based semiconductor technology is found



Power Semiconductors and Applications



Various NTD silicon based power devices

Various high power applications using NTD based power semiconductor devices

Neutron Transmutation Doped (NTD) silicon has the lowest resistivity variation of any crystalline silicon product on the market.

- This is of paramount importance for high power semiconductor devices working under extreme loads.
- Allowing for assemblies of devices in large complex systems.

NTD Silicon Future

Smaller diameters, <8"

- Conversion to larger diameters
- Legacy products to run "untouched" at device manufactures to end of life
- Not all devices make sense on an 8" wafer
- Demand for legacy products will continue at certain level

NTD Silicon need to keep its advantage towards competing products by improving/narrowing

- Target variation from batch to batch
- Axial resistivity gradient within irradiation batch

Resistivity Target Tolerance	**±3 %**
Axial Resistivity (batch)	**<3 %**

"NTD-Si Aliance 4 Net Zero" to

- Increase political awareness and support
- Secure stable and sufficient irradiation capacity

NTD Silicon Future

Increasing demand for 8”

- Driven by the worldwide increased electrification and power consumption
- Often part of large projects (project driven demand)
- More irradiation capacity need to support future demand

Possibility for NTD to capture marked shares from e.g. gas phased doped silicon (PFZ) even in lower voltage range of the high-power segment

- Requires a stable and sufficient irradiation capacity constantly available across several irradiation sites, quarter after quarter
- More 8” irradiation capacity needed

Planning to build a new NTD Silicon facility:

- Thermal neutrons preferred (D2O) for Silicon
- Focus on 8” and 12” (next diameter), limited ≤6”

	Required Fluence ($E+17\ n/cm^2$)	Corresponding Resistivity ($\Omega\cdot cm$)
Expected targets for NTD silicon	0.2 – 2.6 (7.4)	1,200 – 100 (35)

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Thank You

Learn More on
Our Website

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