

**OKMETIC**

# **Semiconductor Physics Course 2022**

**Dr. Atte Haapalinna, Chief Technology officer (CTO)**

**Dr. Heikki Holmberg, Senior Technology Development Manager**

**M.Sc. Jonne Vähänissi, Process Development Engineer (DRIE)**

**15th November 2022**

# OKMETIC

ADVANCED SILICON WAFERS SINCE 1985

## BASIC NUMBERS

**Net sales:** 127 M€ (2021)

**Investments:** > 100 M€ (2017-2021)

**Employees:** ~ 620, Increased by 30-50 per year last 4 years

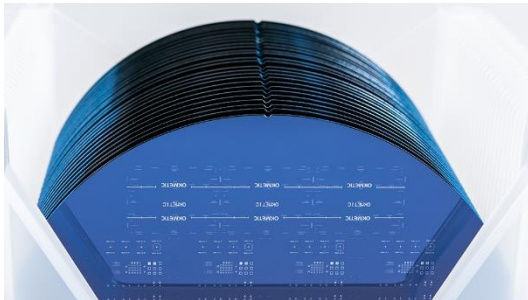
**R&D spending:** over 4% of sales Increased from 3 M€ during last 4 years

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



**400 M€ New investment announced, over 500 new jobs**

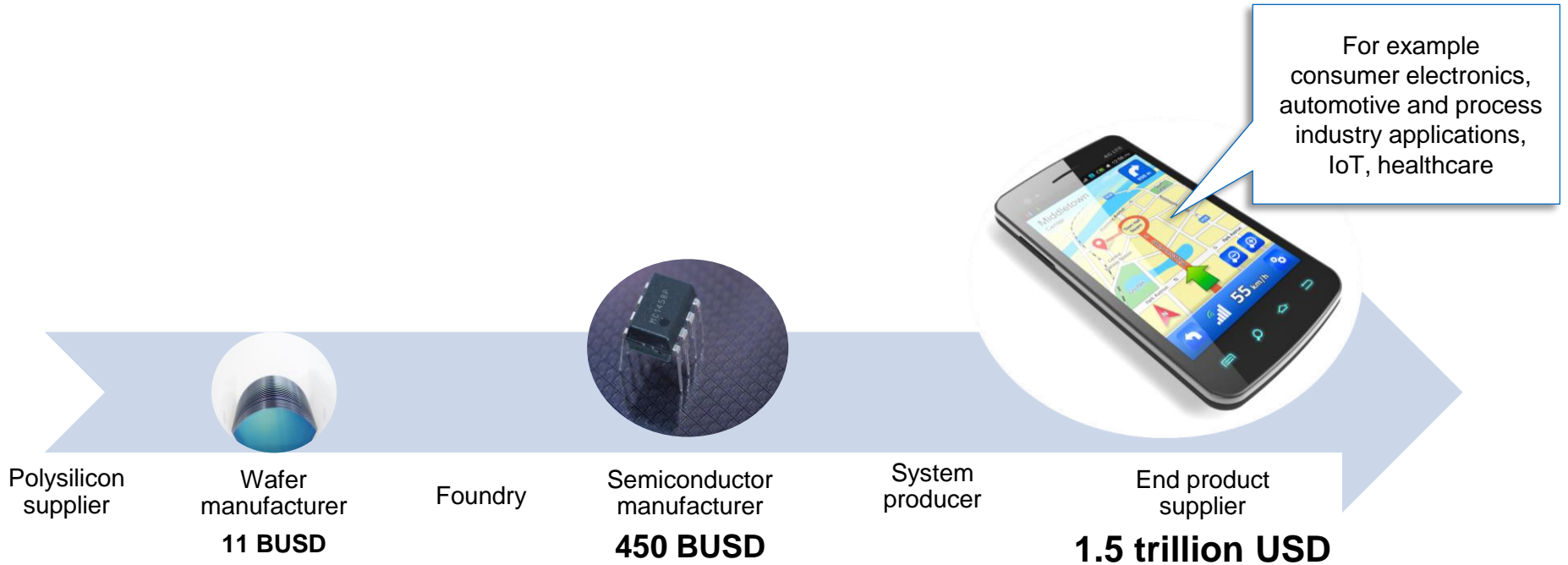
- Building starts early 2023
- Production starts 2025
- Focus mainly on capacity but also capability improvements for 200 mm wafers



- 7<sup>th</sup> largest wafer manufacturer in world
- HQ and production in Finland
- Sales and Tech support worldwide
- #1 wafer supplier for MEMS and sensors
- Over 2 million wafers delivered for the RF market, deliveries to double in 2021



# We operate in the beginning of the electronics value chain



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

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## Crystals

- High resistivities up to and beyond 7 kOhm-cm
- Low resistivities below 1 mOhm-cm
- Different crystal materials, dopants and orientations

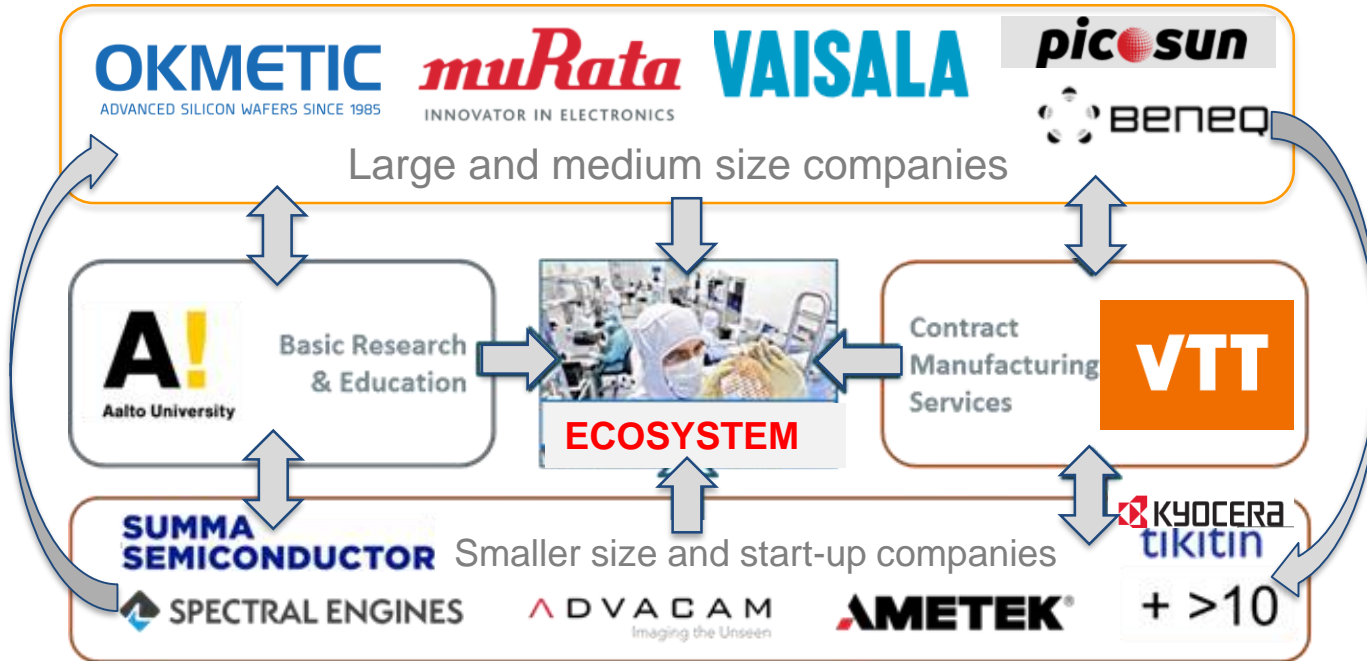


## Wafers

- Bonded SOI (Silicon-On-Insulator) wafer family
- DSP (Double Side Polished) wafers
- SSP (Single Side Polished) wafers
- RFSi™ wafers (High Resistivity for RF devices)

# Semiconductor ecosystem in Finland

# 1 Billion € Microelectronics Ecosystem in Finland

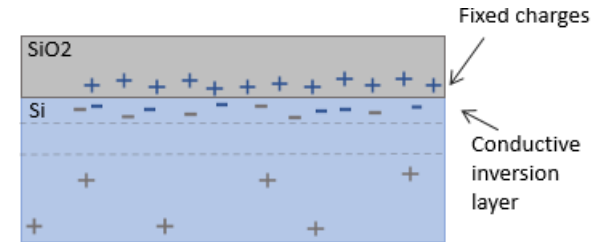


- Finnish Microelectronics ecosystem is well connected and recognized in the world
- Finnish companies are technology leaders in their own field and can offer versatile high tech jobs
- Lot of cooperation with international world leading companies
- Not dependent of any individual market or business area
- Companies are R&D, export and growth-driven
- Lot of new investment done by companies in Finland during last 3 years and more investment to come

# Course Examples

# RF substrate loss and nonlinearity

- Performance of RF devices utilizing highly resistive Si wafers suffers from **parasitic surface conductance (PSC)**:  
A highly conductive parasitic layer is induced below the buried oxide, which causes unwanted coupling of the electric field to the conductive layer. This unwanted coupling gives rise to signal distortion and nonlinearity (harmonic and intermodular distortion) [1, 2]
- With **Okmetic Engineered High Resistivity wafers (RFSi®)** and novel passivation technology incorporating A-MCz® highly resistive crystal with trap-rich surface treatment, these substrate-induced nonlinearity effects are diminished extremely effectively



- [1] C. R. Neve, and J. P. Raskin, "RF harmonic distortion of CPW lines on HR-Si and trap-rich HR-Si substrates", IEEE Transactions on Electron Devices, vol 59, no. 4, pp. 924-932, 2012
- [2] K. B. Ali, C. R. Neve, Y. Shim, M. Rais-Zadeh, and J. P. Raskin, "Non-linear characteristics of passive elements on trap-rich high resistivity Si substrates" In 2014 IEEE 14th Topical Meeting on Silicon Monolithic Integrated Circuits in Rf Systems, 2014, pp. 4-6

## Trap rich layer

Optimized A-MCz® silicon wafer with low O<sub>i</sub> and >7000 Ohm-cm resistivity

- Surface microroughness below 0.5 nm
- TTV below < 700 nm (wafer thickness 625 um)



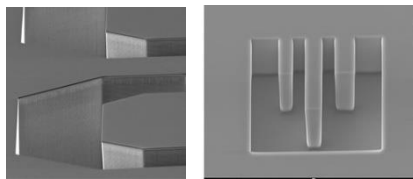
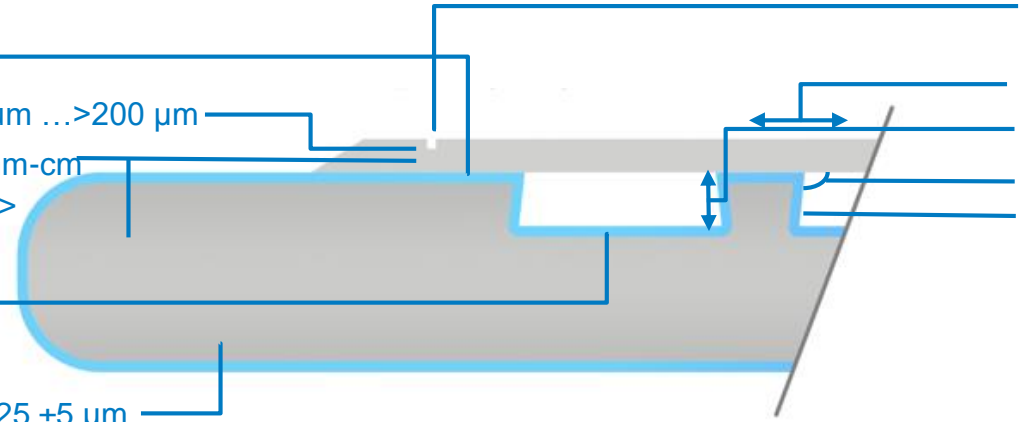
# Okmetic baseline for 150 mm and 200 mm C-SOI® wafer

## Wafer parameters

- Hermetic sealing
- Device layer thickness:  $4 \pm 0.5 \mu\text{m} \dots >200 \mu\text{m}$
- Resistivity:  $< 0.001 \dots > 7,000 \text{ Ohm-cm}$
- Orientation:  $\langle 100 \rangle, \langle 110 \rangle, \langle 111 \rangle$
- Dopant: B or P
- BOX thickness:  $0.5 \dots 2 \mu\text{m}$   
grown on handle
- Handle wafer thickness:  $380 \dots 725 \pm 5 \mu\text{m}$

## Patterning parameters

- Minimum CD  $2 \mu\text{m}$
- VIS-overlay  $\pm 0.35 \mu\text{m}$
- IR-overlay  $\pm 1 \mu\text{m}$
- Depth  $10 \dots 100 \mu\text{m} \pm 5\%$
- Re-entrant profile  $91 \dots 95^\circ$
- Scallop size  $< 1 \mu\text{m}$



# Working in Okmetic as young engineer

# Personal Page: Jonne Vähänissi

- 2012 – 2019: School of Electrical engineering
- 2015 – 2018: Research assistant – Aalto University
- 2018 – 2019: Research assistant – VTT, MEMS team
  - M.Sc. (Tech.)
    - Major: Micro- and nanotechnology / Advanced materials and photonics
    - Master's thesis: *"Xenon difluoride etching of sacrificial layers for fabrication of microelectromechanical devices"*
- 2019 – : Process Development Engineer – Okmetic, patterning
  - Deep reactive-ion Etching (DRIE)

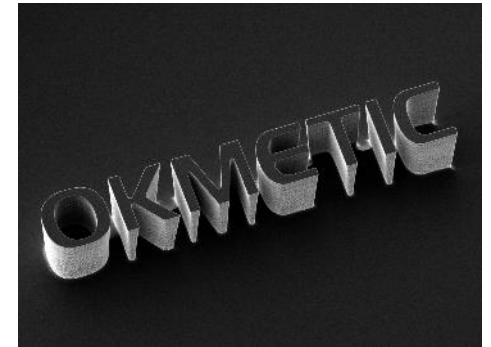
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**M.Sc. (Tech.) Jonne Vähänissi**  
Process Development Engineer

**Okmetic Oy**

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# Working as a Process Development Engineer (DRIE)

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## Development

- Process development
  - Project management
  - Planning
  - Experimental work
  - Data analysis
  - Documentation/reporting
- Internal R&D projects
  - Patterning team
  - Okmetic
- External R&D projects

## Production

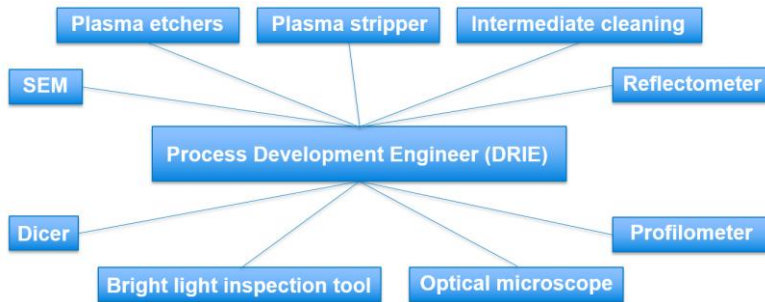
- Statistical Process Control (SPC)
  - Measurements
    - SEM
    - Profilometer
    - Reflectometer
    - Optical microscope
  - Data management
- Training operators and engineers
  - Tool training
  - Work instructions
  - New designs/products

## Maintenance

- Overall understanding of tools:
  - Basic maintenance
  - Error handling
  - Hardware
  - Assisting equipment engineers
- Communication with tool manufacturers
  - Updates
  - Training

# Why I enjoy working at Okmetec in patterning

- State-of-the-art tools:



- Colleagues:

- Different backgrounds
- Dealing with challenges together and having fun at the same time

- Lots of experience and practical knowledge from semiconductor industry



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**Thank you!**

Any questions?

# Background slides

# Many technology experts are needed in semiconductor technology

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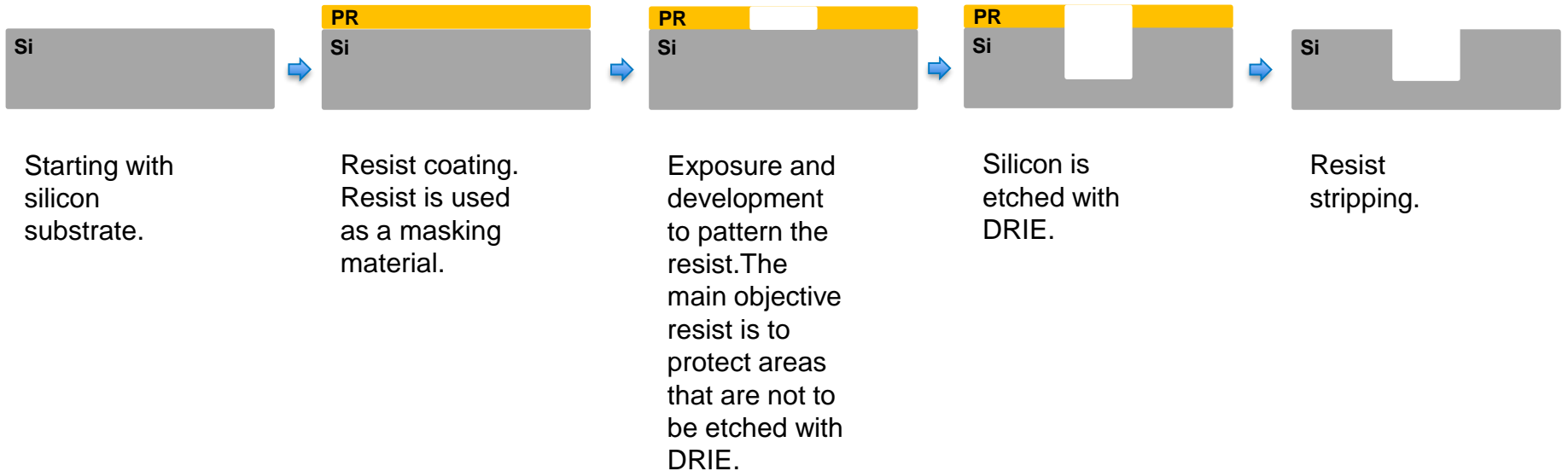
## Both theoretical and practical skills are needed

- Deep knowledge of following fields (one of this field)
  - Semiconductor physics, fabrication and device technology
  - Optoelectronics
  - Material physics
  - Chemistry
  - Nanotechnology
- Supporting fields
  - Measurement metrology and different characterization technology related to materials
  - Statistics
  - Quality system knowledge
  - AI and big data
  - Reliability
- Nice to have skills
  - Programming
  - Project management
  - Doctoral degree
  - Clean room experience

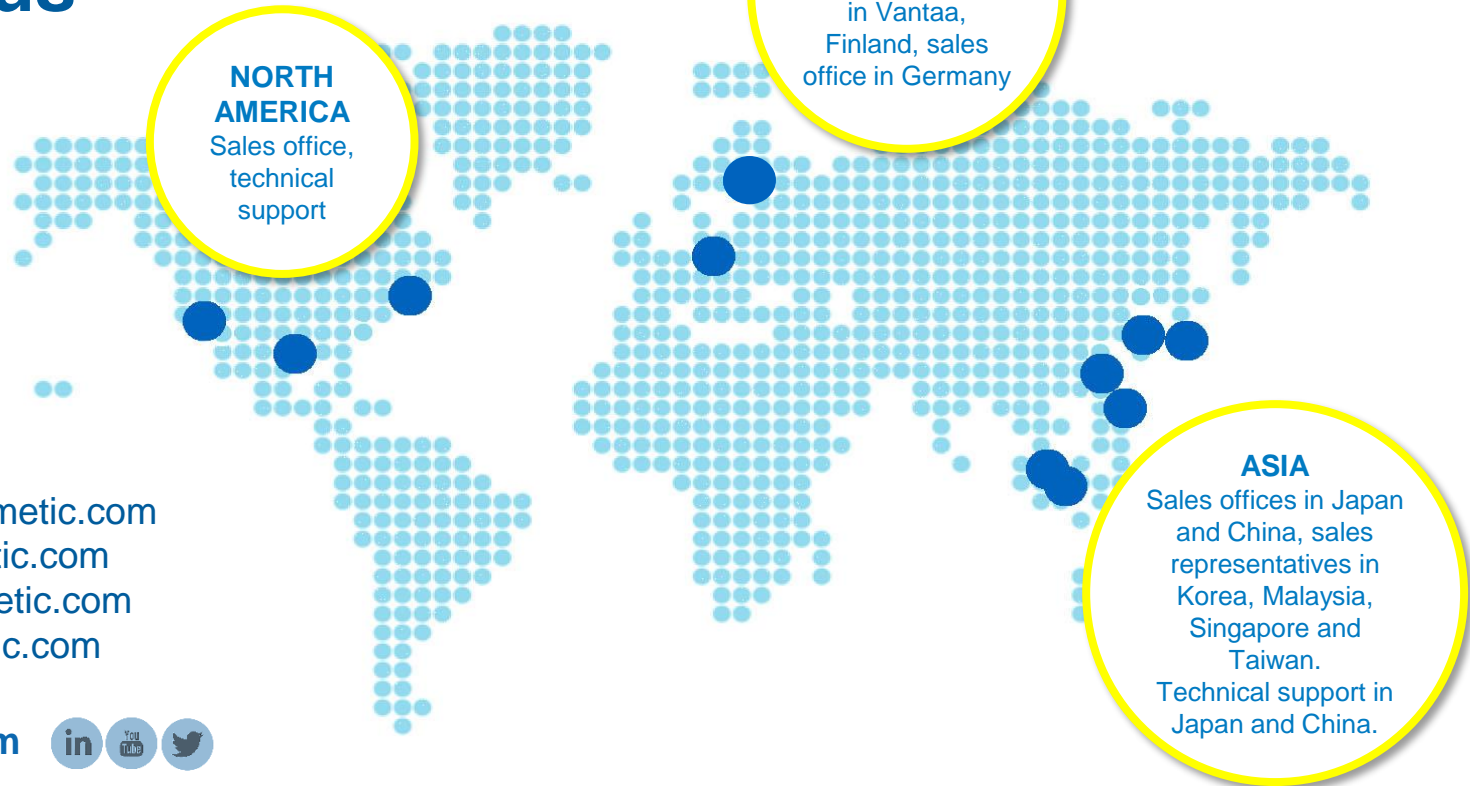


# What is patterning?

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# Contact us



## NORTH AMERICA

Sales office,  
technical  
support

## EUROPE

HQ, plant, sales,  
technical support  
in Vantaa,  
Finland, sales  
office in Germany

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and China, sales  
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