

OKMETIC

Data management as a part of semiconductor production process development

**Sustainable Manufacturing Launch
March 5th 2020**

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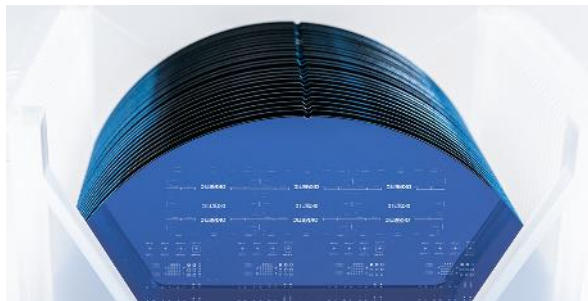
**BUSINESS
FINLAND**

World's leading supplier of silicon wafers for most of the top 30 MEMS manufacturers

- Focusing on bonded SOI products and specialized 150-200 mm wafers
- Cutting-edge solutions to customers who are world's leading manufacturers

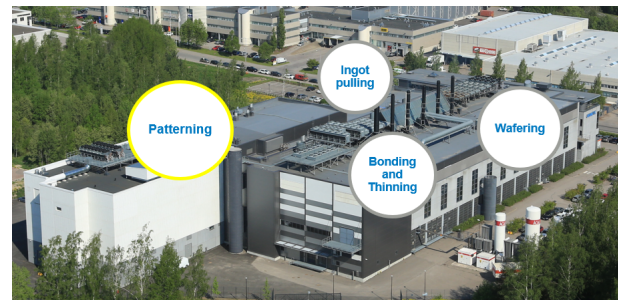


Net sales: 107 M€
Investments:
> 100 M€ (2017-2021)
Employees: ~ 450



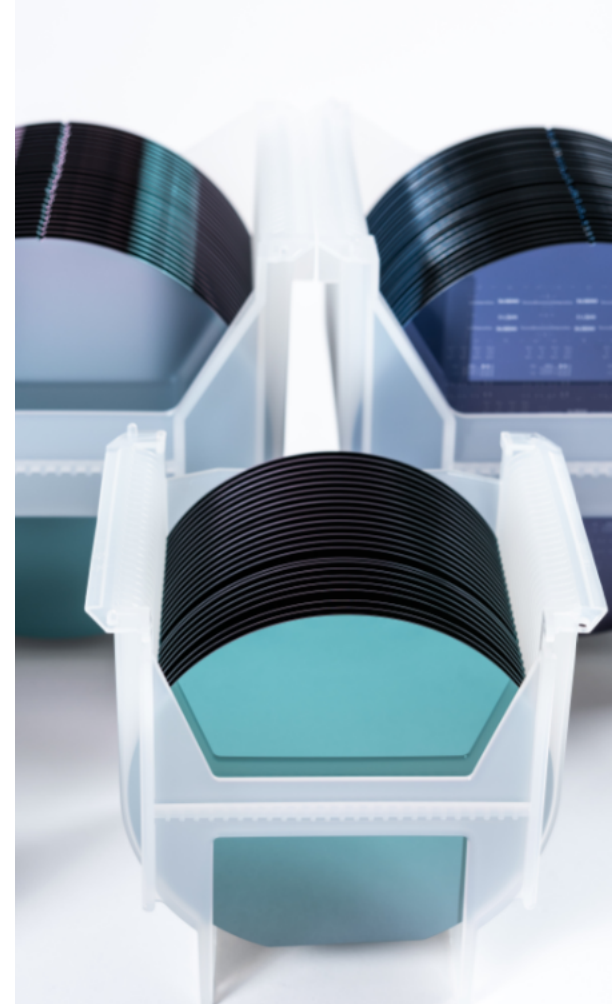
Headquarters and production in Finland with sales and technical applications support worldwide

- 800 square meter dedicated patterning line

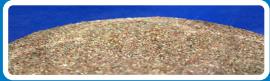


Focusing on the niche markets of semiconductor industry

- **Sensor industry (59% of net sales)**
 - Okmetic is the market leader
 - Material for MEMS and other sensor applications
- **Discrete & analog industry (41% of net sales)**
 - Okmetic is a valued and reliable supplier
 - High resistivity and high voltage SOI materials



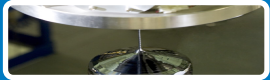
From sand to silicon chips



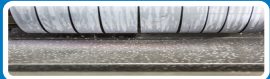
Quartz sand



Hyperpure polysilicon



Crystal growth



Ingot cutting, grinding, slicing



Silicon wafer processing



Wafer inspection and packaging



1000's of devices manufactured per wafer

Edge rounding

Lapping

Acid/Caustic etching

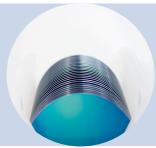
CVD deposition (optional)

Wafer grinding (optional)

CMP polishing

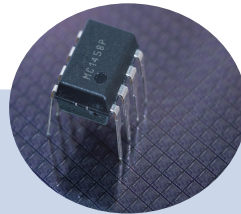
Final cleaning

Silicon wafer is the plate on which technology is built



Silicon wafer
11 Bn USD

(Foundry)



Semiconductors
410 Bn USD

(Sub-systems)



Electronic products
**>1,8 trillion
USD**

Consumer electronics,
automotive and
industrial electronics,
IoT, medical electronics

Data management contains

- **Tool data integration**

- Silicon Wafer line tools vary greatly in applicability

- **Ship to control**

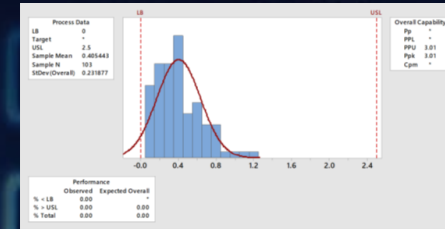
- Control of statistical outliers from shipped material

- **Statistical process control**

- Application through six sigma approach

- **Effective data mining**

- Statistical analysis of product data, primarily to support process development



Advanced data management targets in semiconductor materials

Enhanced process control

- Improved yield, providing
Profitability
Reduced environmental impact

Reduced product variation

- Reduction / elimination of customer process incursions with
Better customer satisfaction
Reduced need for corrective actions

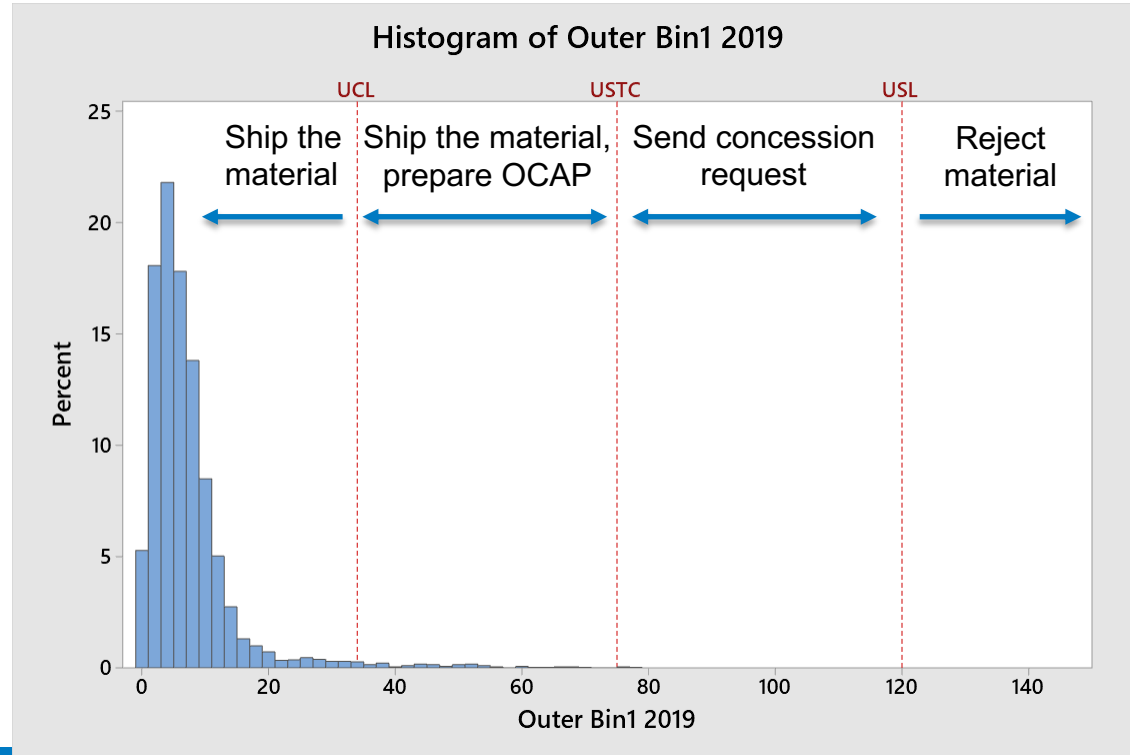
Provision of detailed product data for customers

- Enabling customers to further improve their processes,
Building trust
Improving customer yields
Enhancing reliability of customer products (ppb or even ppt targets)



Ship-to-Control (STC) in a nutshell

- The idea is to introduce different material quality *decision zones* based on statistical calculations.
- The precise position of decision zones are not unambiguous
 - Zones may overlap
- Technical-economically viable accept / reject decision is not straightforward.



STC basics:

Three sigma rule, alpha risk and P (false alarm)

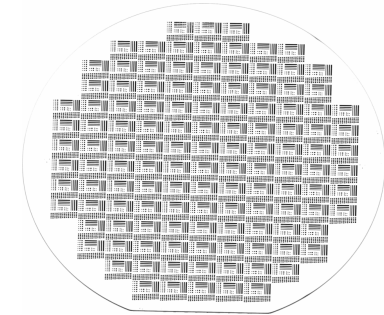
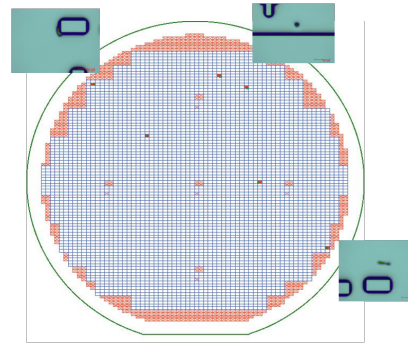
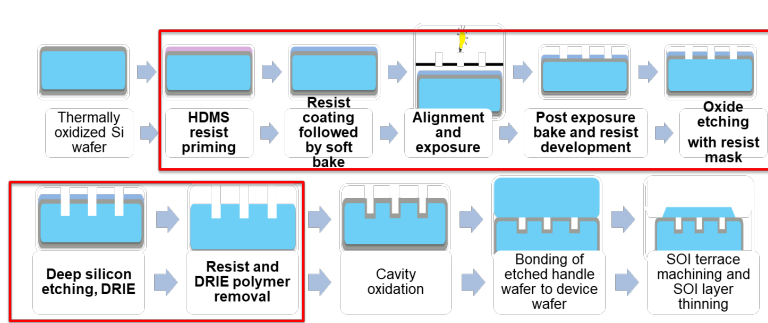
False alarm probability | 0.0027 |
0.9973

- Three sigma rule, generally required industry standard, means that ~0.27% of observations can be OOC even when there was no specific reason for the deviation.
- Alpha risk is the number which indicates the false alarm probability.
- For additional follow up items, control limits must be adjusted in order to keep the total alpha risk, alpha_total, at 0.27%.
- These control limit settings apply only for stable processes. Real world processes include some acceptable drift
- Control limit settings $CL = \text{Mean} \pm 4 \times \text{Sigma}$ is a simple and a good approximation when following multiple items simultaneously.

No controlled parameters	Probability between LCL and UCL (%)	False alarm probability (%)	t_crit
1	0.9973	0.2700	3.000
2	0.9946	0.5392	3.205
3	0.9919	0.8078	3.320
4	0.9892	1.0756	3.399
5	0.9866	1.3426	3.460
6	0.9839	1.6090	3.509
7	0.9813	1.8746	3.549
8	0.9786	2.1395	3.584
9	0.9760	2.4037	3.615
10	0.9733	2.6672	3.642
...
100	0.7631	23.6884	4.197
...
1000	0.0670	93.3026	4.692
...
10000	0.0000	100.0000	5.143
...
100000	0.0000	100.0000	5.560

Provision of detailed product data for customers: Sample case C-SOI®

For advanced products with embedded structures, wafer level and chip level data enables customer to analyse their device level data, and reject individual dies with observed anomalies



Examples of chip level data collected from C-SOI® process:

Automated optical
microscopy (AVI)

Scanning acoustic
microscopy (SAM)