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Finland's Microelectronics and Photonics Industry:

DRIVING SUSTAINABILITY IN THE SEMICONDUCTOR AGE

As industries in the U.S. and worldwide pivot toward a greener and more digitally connected future, Finland is carving out a prominent role in the global semiconductor and photonics market. Chips and photonics, often referred to as the "brains and nerves" of modern technology, are essential for innovations across AI, renewable energy systems, autonomous vehicles, 5G networks, smart cities and more. With demand for these components skyrocketing, the semiconductor sector is poised to be a $1 trillion industry by 2030.

Finland's ambition is clear: leading the way in developing sustainable solutions for this critical industry. While traditional semiconductor manufacturing has often been associated with high energy consumption and environmental costs, Finland is taking a different path. Through specialization, innovation and collaboration, the country aims to set a new standard for sustainability in microelectronics.

What sets Finland apart is its holistic growth strategy. Finland's government, academic institutions and private sector are working hand in hand to establish a robust ecosystem that supports both technological advancements and environmental goals.

Media contact: Diana Rissetto | diana@thatcherandco.com | 732.397.1927
Kenny Vesey | kenny@thatcherandco.com | 973.518.3644

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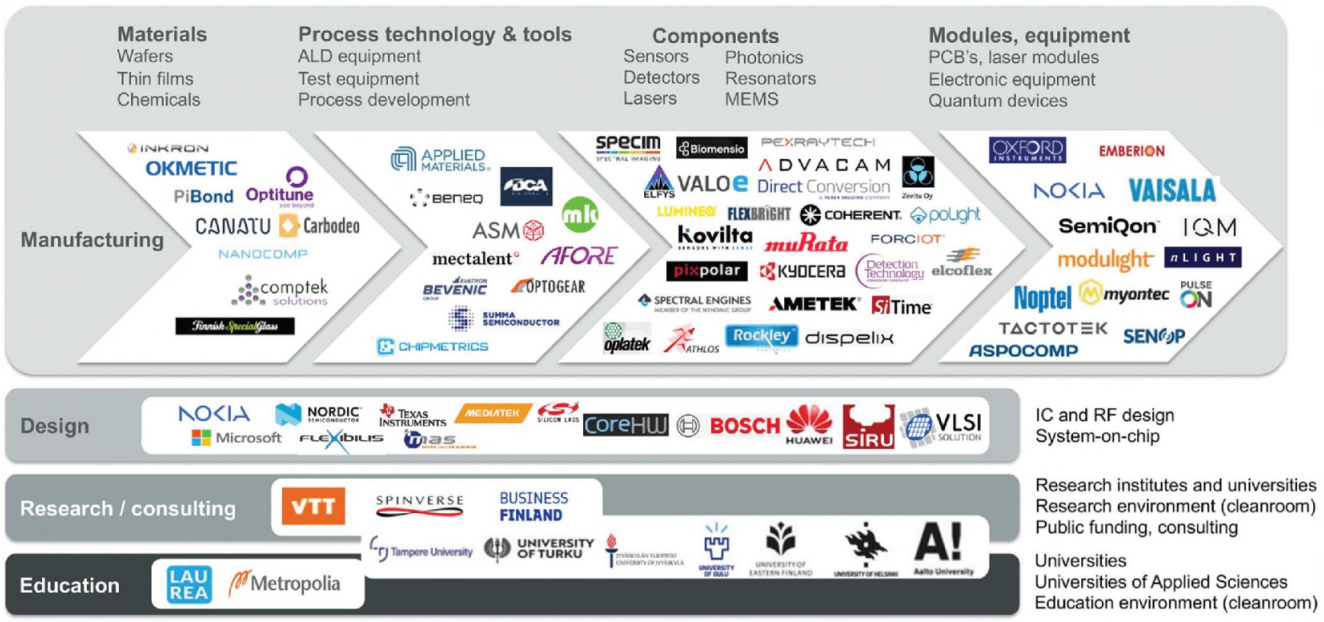
These renowned Finnish players are helping shape the future of sustainable electronics:

- **Nokia:** Through its Competitive Edge program, Nokia is pioneering energy-efficient, carbon-neutral future networks.
- **ABB Oy:** A global leader in energy efficiency and industrial automation, ABB is driving innovation in power electronics for sustainable industries.
- **VTT:** Finland's national research institute is at the forefront of developing green technologies in microelectronics and photonics.
- **Vaisala:** Renowned for its precision environmental measurement tools, Vaisala is contributing to smarter, greener systems worldwide.
- **Murata (via VTI Technologies acquisition):** Specializing in Micro-Electro-Mechanical Systems (MEMS)-based sensor technology, Murata is leveraging local expertise for automotive and biomedical applications.
- **Applied Materials (via Picosun acquisition):** By acquiring Picosun, a pioneer in Atomic Layer Deposition (ALD) – a Finnish invention that enables ultra-precise coatings with lower energy and material consumption – Applied Materials has strengthened Finland's role in next-generation chip manufacturing technologies.
- **Bosch (via Minima Processor acquisition):** Bosch tapped into Finland's ultra-low power chip design know-how to bolster energy-efficient embedded systems.



This graphic illustrates the versatile world of the semiconductor related ecosystem in Finland.
CREDIT: Technologies Industries of Finland

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In 2024, Finland's semiconductor industry released its growth strategy, Chips of the North, which outlines key priorities with the goal to triple annual revenue to €5–6 billion by 2035, grow the workforce to 20,000, create more than 15,000 ancillary jobs and generate an indirect economic impact of €90–180 billion over 10 years.

Chips of the North Growth Opportunities

- **Advanced Materials & Processing Technologies:** Finland is a global leader in ALD, with the world's highest cluster of ALD reactors (approximately 90 in 2023) and more than 500 R&D experts and notable professors in the field.
- **Chip Design:** Home to the second-highest number of System-on-Chip (SoC) patents per capita in Europe, Finland continues to be a leader in SoC and semiconductor chip design. Research institutions and companies like Nokia and Microsoft support eco-friendly chip production focused on energy efficiency, carbon reduction and material recycling.
- **MEMS & Sensor Technologies:** Finland has a strong cluster in Micro-Electro-Mechanical Systems (MEMS), with globally recognized companies such as MuRata, Vaisala, Okmetic and Kyocera, alongside VTT National Research Center of Finland. These organizations are at the forefront of sensor applications for industrial automation, healthcare and environmental monitoring.
- **Photonics & Imaging Technologies:** Finnish organizations such as Dispelix and VTT are advancing applications from augmented reality to autonomous vehicle sensors, with growing interest from U.S. partners. In October 2024, Dispelix announced a collaboration with Collins Aerospace, an RTX business, to develop technology for aerospace and defense applications.
- **Quantum Computing:** Finland is home to a rapidly developing quantum ecosystem, with leading companies IQM and SemiQon emerging as spin-offs from Aalto University and VTT. Bluefors, another key player, specializes in cryogenic measurement systems crucial for quantum computing.

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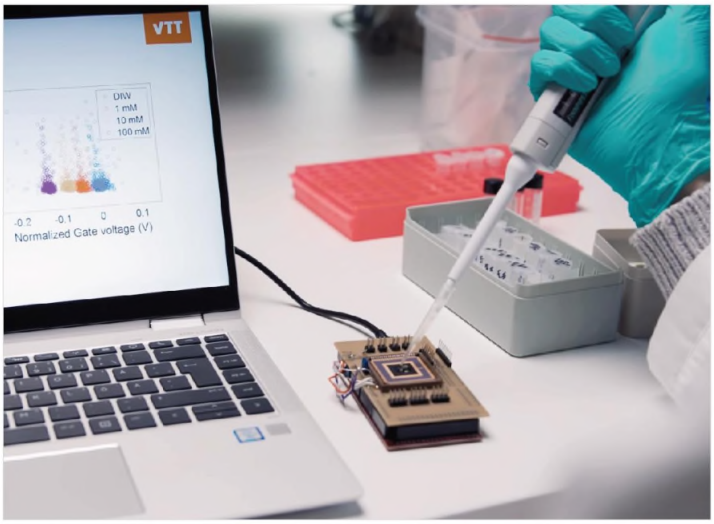
Specialization: Finland's Secret to Semiconductor Success

Finland's unique approach to microelectronics and photonics lies in its history of specialization. The country's legacy iSoC (integrating System-on-Chip) design, dating back to Nokia's dominance in telecom chip manufacturing, has provided a solid foundation for broader expertise.



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Rather than competing broadly, Finland has developed world-class expertise including AD/DA conversion, MEMS, imaging, photonics, radio frequency and quantum chips, components increasingly vital in applications like sensors, autonomous systems, smart infrastructure and healthcare.

Finland's MEMS ecosystem exemplifies this specialized strength. From wafer fabrication to complete sensor systems, Finland covers the entire value chain. Leading companies like Vaisala have set global benchmarks in environmental and industrial sensing, powered by innovations born in Finnish R&D.

Collaboration between universities, research institutions and companies has led to a seamless integration of education, innovation and commercialization. This fusion is now being scaled through the Chips from Finland initiative, which aims to form a national chip competence center, anchored by Tampere University's SoC Hub and Aalto University's circuit design lab. This hub will support cross-sector innovation, facilitate R&D partnerships and drive the development of chips for smart devices, climate technologies and digital industries.

A Sustainability Revolution in Semiconductor Manufacturing

With the chip industry facing growing pressure to reduce emissions and waste, Finland is leading a sustainability revolution rooted in lifecycle innovation, clean energy and smart design.

At the heart of this shift is the Chip Zero program. Led by Applied Materials (via Picosun), the initiative focuses on reducing the carbon footprint of semiconductor production through material efficiency, smarter processes and breakthrough technologies like ALD.

This is amplified by Finland's unique energy profile. Over 95% of the country's electricity is produced from low- or zero-carbon sources, including nuclear, hydro and wind. Finland's cool climate further reduces energy needs for data center and fab cooling, helping cut operational emissions.

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Beyond cleaner energy, Finland is investing heavily in sustainable chip innovation environments:

- **Kvanttinova:** An industry-driven piloting and development hub that offers easy access to VTT and Aalto University piloting facilities for development of microelectronics and quantum technology.

- **SIPFAB:** A chip and system-in-package development line in Tampere that enables the agile creation and testing of environmentally friendly, customized and packaged chip systems.

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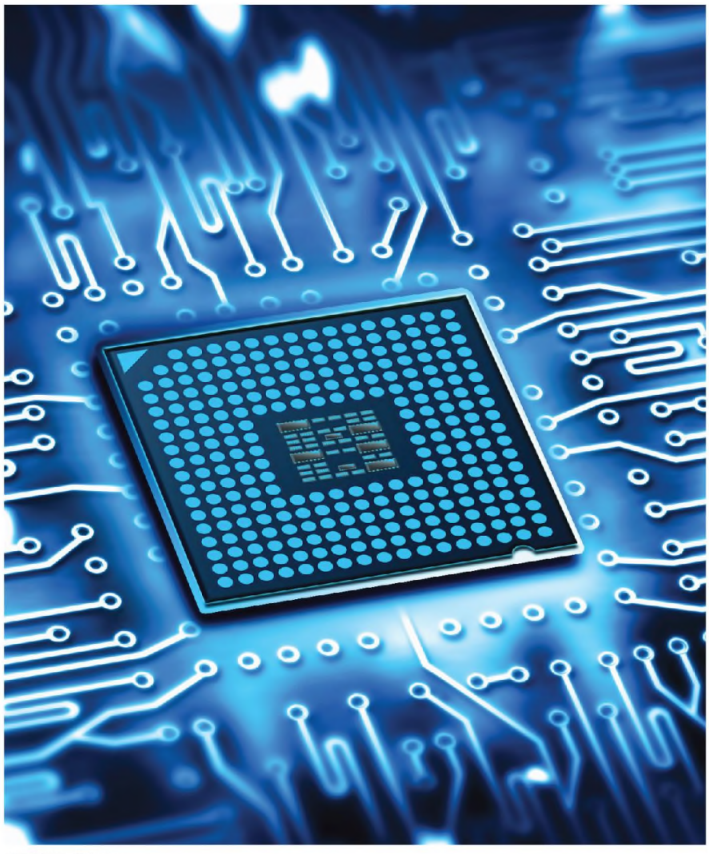
Together, these initiatives form a closed-loop R&D-to-production ecosystem that supports sustainable innovation from prototyping to commercialization. Finland's model ensures that new microelectronic technologies are designed with their full environmental lifecycle in mind – minimizing waste, energy use and water consumption.

Opportunities for Collaboration with U.S. Markets



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Finland is an ideal partner for the U.S. semiconductor industry. Its political stability, skilled workforce, clean energy, accessible water supply and competitive labor costs make it a preferred location for high-tech design and manufacturing.

Major U.S. corporations, including Microsoft, Nvidia, Google, Qualcomm and Texas Instruments have already tapped into Finland's deep tech ecosystem. These firms see Finland not just as a European R&D hub, but as a driver of the next-generation technologies that will shape global industries.

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The U.S. semiconductor industry shares many of Finland's priorities: sustainability, innovation and advanced manufacturing. Joint R&D and co-investment in Finland's pilot platforms and research hubs offer unique advantages for U.S. states and companies focused on climate tech, smart systems and digital infrastructure, including:

California

As the home of Silicon Valley, **California remains a global leader in semiconductor innovation**, home to tech giants like NVIDIA, Apple and AMD. The state's dynamic ecosystem of startups, research institutions and advanced fabrication facilities presents fertile ground for collaboration with Finland's sustainable microelectronics sector. Finland's "Chip Zero" initiative aligns with California's climate-forward policies, offering solutions for low-power chip design and eco-efficient manufacturing that meet the region's high environmental standards.

Additionally, **Finland's cutting-edge photonics and quantum technologies can complement California's leadership in Al, autonomous vehicles and next-gen computing**. Joint efforts can accelerate breakthroughs in chip performance and system integration, supporting California's push to remain at the forefront of global tech innovation while promoting a greener, more sustainable industry.

Arizona

Arizona is a major player in semiconductor manufacturing and solar energy. Companies like Intel and ON Semiconductor are driving the state's economy, making it a natural partner for Finland's sustainable microelectronics and photonics technologies. Finland's "Chip Zero" initiative can help Arizona's semiconductor manufacturers meet growing demands for energy-efficient production processes while aligning with the industry's sustainability goals.

Moreover, **Finnish advancements in photonics, such as high-efficiency optical components like ELFys photodetectors, can bolster Arizona's solar power industry by improving the performance and cost-effectiveness of solar panels.** These innovations will not only enhance energy generation but also support Arizona's broader clean energy ambitions.

Texas

As the energy capital of the U.S., Texas is a prime market for Finnish innovations in power electronics and loT technologies. Multinational companies like Eaton, which operates a factory in Vantaa, offer expertise in power management systems critical for grid stability and renewable energy integration. These solutions are especially relevant for Texas, which has faced significant energy reliability challenges in recent years.

The loT sector in Texas, supported by companies like Silicon Labs and Tesla's operations in Austin, also stands to benefit from Finland's advanced sensor technologies and energy-efficient semiconductors. **By collaborating with Finnish innovators, Texas can enhance its electric vehicle (EV) manufacturing capabilities and expand its leadership in smart technology applications.**

North Carolina

North Carolina is a hub for clean technology and advanced manufacturing, with companies like Wolfspeed, Cree LED and Qorvo driving innovation. Finland's focus on sustainable microelectronics directly aligns with these industries, particularly through initiatives like "Chip Zero" that support energy-efficient semiconductor production.

Photonics advancements from Finland can also play a transformative role in North Carolina's clean tech economy. Applications in precision manufacturing offer immediate benefits to local industries while advancing the state's sustainability goals. Finnish expertise in renewable energy systems, such as smart grid technologies, can further enhance North Carolina's efforts to create a stable and resilient energy infrastructure.

By fostering partnerships between Finnish innovators and U.S. companies, both regions stand to benefit from shared innovation and responsible growth. Finland's track record and forward-looking policies make it a strategic ally for shaping the next era of global semiconductors.

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BUSINESS FINLAND Media contact: Diana Rissetto | diana@thatcherandco.com | 732.397.1927
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