PUBLISHABLE SUMMARY

July 2024 – December 2025

1. Context and overall objectives of the project

The proliferation of Internet of Things (IoT) applications across the aerospace, automotive, power generation, and manufacturing sectors—particularly within the circular economy—has necessitated the development of electronics capable of enduring extreme operating conditions. Conventional semiconductor-based electronics frequently fail in high-temperature or high-radiation environments. To address these limitations, the i-EDGE project introduces a novel Nanoelectromechanical (NEM) switch technology platform specifically engineered for resilient edge computing.

The i-EDGE platform leverages the physical properties of NEM switches to provide robust performance characteristics that surpass traditional CMOS limitations:

- Thermal Resilience: Reliable operation in ambient temperatures reaching 300°C.
- Radiation Hardness: Demonstrated resistance to ionising radiation doses up to 1 Mrad.
- Energy Efficiency: The mechanical nature of the switches ensures zero standby power consumption, significantly optimising the energy profile of edge nodes.

The project focuses on the development of a proof-of-concept System-on-Chip (SoC) demonstrator.

This integrated IoT node is comprised of the following critical subsystems:

- NEM-based FPGA: A Field-Programmable Gate Array fabric utilising NEM switches for reconfigurable digital logic.
- Non-Volatile Memory: Integrated memory arrays for persistent data storage in harsh conditions.
- Analog Utility Blocks: Modules for sensor data readout, signal conditioning, and data communication.
- Power Management: A high-temperature capacitor bank supported by a wireless power receiver for trickle-charging.
- Data Transceiver: An optimised transceiver for efficient telemetry and external interfacing.

Beyond hardware, i-EDGE will deliver a dedicated Physical Design Kit (PDK). This software suite will provide the necessary models for design and circuit simulation, streamlining the transition from conceptual architecture to physical implementation for application engineers. Building upon foundational research at Technology Readiness Level 3 (TRL 3), i-EDGE aims to advance this technology to TRL 5. The technology will be validated through a functional condition-monitoring application tailored for industrial IoT processes.

The i-EDGE consortium encompasses a multidisciplinary supply chain, spanning from fundamental cell design to full-scale SoC integration. By establishing a roadmap for pilot manufacturing within Europe, the project directly supports the objectives of the EU Chips Act, enhancing regional sovereignty in specialised semiconductor design and high-endurance microelectronics.

2. Work performed and main achievements

Within those 18 months of the project, we have:

- Adapted the system specifications to the project's technical progress and input provided by its Business Interest Group (BIG)
- Optimised all key components: NEM switches, non-volatile memory, FPGA, and utility circuits for wireless power, sensor data, and communication.
- Maintained and extensded of the i-EDGE toolkit for designing and simulating circuits. This toolkit will be accessible to others even without deep knowledge of NEMS, promoting future use of the technology.
- Fabricated and tested various NEM switches (3, 4, and 7 terminals).
- Integrated NEM switches into existing manufacturing processes.
- Thoroughly studied the options for small-scale manufacturing
- Exchanged with the Business Interest Group (BIG) to explore future uses and commercialisation of the i-EDGE technology.

3. Progress beyond the state of the art

Scientific Impact:

The i-EDGE project has established a robust scholarly foundation, with 6 manuscripts either appearing in or currently under preparation for high-impact, peer-reviewed journals in this reporting period, together with more than 10 conference contributions and additional communication and dissemination activities. These contributions substantiate the project's role in advancing the state-of-the-art in nanoelectromechanical (NEM) switch electronics. By disseminating these innovative methodologies and experimental results, the project actively redefines the technical boundaries of resilient microelectromechanical systems and high-temperature digital logic.

Beyond Academia:

The i-EDGE project maintains a strategic vision that transcends fundamental academic inquiry, prioritising a robust pathway toward commercial industrialisation. Central to this objective is the identification of high-value 'incubator applications' targeting high-readiness implementations such as standalone non-volatile memory arrays for extreme environments. By deploying these specific initial use cases, i-EDGE demonstrates the empirical utility of NEM technology to secure industrial partnerships and venture capital. This integrated focus on scientific rigor and commercial viability positions the consortium to effectively bridge the 'valley of death' between laboratory-scale research and scalable, market-ready microelectronic solutions.

Policy relevant evidence of your project

The i-EDGE project provides a critical technological foundation for several high-priority European Union initiatives, bridging the gap between advanced microelectronics and environmental sustainability.

i-EDGE contributes to the objectives of the EU Chips Act by fostering a robust, indigenous semiconductor ecosystem. By developing a Nanoelectromechanical (NEM) switch platform independent of non-European intellectual property and manufacturing chains, the project enhances:

- Strategic Autonomy: Reducing dependence on foreign semiconductor foundries for specialised, radiation-hardened, and high-temperature electronics.
- Industrial Competitiveness: Establishing a leadership position for Europe within the global IoT and edge computing markets through the commercialisation of proprietary, resilient hardware.
- Supply Chain Resilience: Enabling complete vertical integration from cell-level design to full System-on-Chip (SoC) fabrication within the EU.

The deployment of NEM-based technology acts as a catalyst for the European Green Deal by enabling sophisticated data acquisition in previously inaccessible, high-energy environments.

- Ultra-Low Power Edge Computing: The inherently zero standby power consumption of NEM switches significantly reduces the carbon footprint of large-scale IoT deployments compared to traditional CMOS architectures.
- Process Optimisation in Extreme Environments: i-EDGE enables real-time sensor integration and edge-level computation within high-heat industrial processes (e.g., industrial kilns and bakery ovens) and aerospace propulsion systems.
- Actionable Intelligence: The high-fidelity telemetry provided by these resilient nodes allows for the precise optimisation of thermodynamic and mechanical processes, directly leading to a measurable reduction in aggregate energy consumption and CO2 emissions.

Partners involved in i-EDGE

AMO	**Gesellschaft für Angewandte Mikro- und Optoelektronik mbH**
KTH	**Kungliga Tekniska högskolan**
TUWIEN	**Technische Universitaet Wien**
Microchip-FR	**Microchip Technology Nantes**
CSEM	**Centre Suisse d'Electronique et de Microtechnique SA – Recherche et Développement**
SCIPROM	**SCIPROM Sàrl**
UNIVBRIS	**University of Bristol**
Microchip-UK	**Microchip Technology Caldicot Limited**

UK Research and Innovation

Schweizerische Eidgenossenschaft
Confédération suisse
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www.i-edge-project.eu