ZeroAMP

PUBLISHABLE SUMMARY

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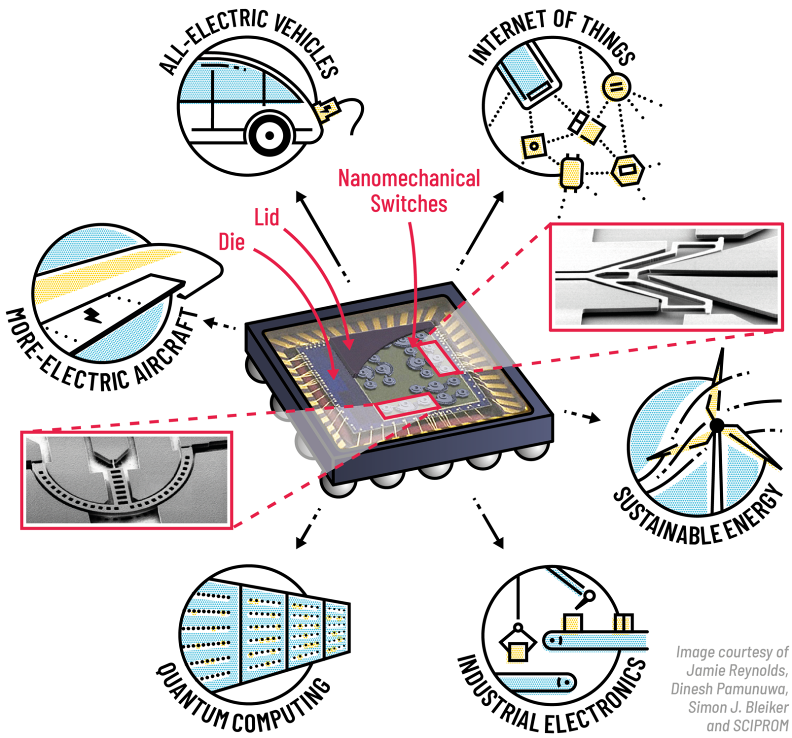
1. Summary of the context and overall objectives of the project

ZeroAMP is a project to develop nanomechanical switch-based processors and memory chips that can work in harsh environmental conditions with very high energy efficiency. Numerous emerging applications such as the Internet-of-Things (IoT), all-electric vehicles, and more-electric aircraft, as well as components used in industrial environments require electronics with some combination of high-temperature capability, radiation hardness and very low energy consumption. Electrostatically operated nanomechanical relays can work at much higher temperatures and radiation levels than conventional transistors and turn off abruptly with zero leakage current in the off state, something that is fundamentally beyond the reach of transistors. Thus, nanomechanical digital technology has the potential to enable a new class of digital processors that meet the requirements of applications with very demanding constraints. This type of disruptive technology solution could hold the key for unlocking the true potential of new and emerging technologies; for example, IoT sensor nodes in remote and hazardous locations that can perform sensing and processing autonomously, entirely on scavenged energy, or electrification of aircraft with electronic controllers replacing heavy hydraulic components.



Markets targeted by ZeroAMP

The main challenges in using nanomechanical relays as digital switches are related to reliability and large-scale integration of relays. Innovative solutions in materials, fabrication processes and designs are being investigated in the ZeroAMP project to address these challenges. The overall objectives of the project are to develop a complete nanomechanical fabrication and integration platform with the flexibility to produce reliable and densely integrated reprogrammable processors and electronic memories for diverse applications. We will test the harsh-environment capability of the technology to operate at extreme temperatures and radiation levels and produce two demonstrators to showcase its potential.

2. Work performed and main results achieved so far

In the first 18 months of the project, we have:

1. engaged with industry working in key sectors (such as the IoT, aerospace, manufacturing, and defence) that benefit from the ZeroAMP technology to refine our specifications;
2. carried out work to improve the reliability of the switch and increase the operational lifetime by developing a carbon-based contact material;
3. developed two types of relays to serve as basic logic switches and memory cells;
4. optimised fabrication process flows for these designs and the special materials used in our switches;
5. developed a complete set of software tool suites for modelling, simulation, and design of large-scale nanomechanical relay circuits;
6. designed a library of basic cells that can be reused to produce all of the planned system demonstrators in our project;
7. carried out investigations to validate critical aspects of our large-scale integration approach;
8. set up testing protocols;
9. started on the fabrication of our first memory and processor prototypes.

For additional information, please visit our project's website at https://www.zeroamp.eu, where a flyer and media kit are available for download. We also have an introductory video at https://vimeo.com/463926354.

3. Progress beyond the state of the art, expected results and potential impacts

By the end of the project, we plan to produce the first ever electronic memory and processor built using nanomechanical technology. In achieving this goal, we expect to produce the first ever nanomechanical processor and memory prototypes as well as significant improvements over the current state-of-the-art in different aspects of the technology. These include a contact coating that can be used as an anti-stiction material in the wider field of micro and nanoelectromechanical systems (MEMS / NEMS), a heterogeneous integration approach that allows disparate technologies to be integrated in the same chip instead of multiple chips placed on a circuit board, efficient computing architectures that leverage the presence of logic, memory and sensors on the same chip, and sealing and packaging technologies to withstand very high temperatures.

We anticipate that the biggest impact of the ZeroAMP project will be in achieving a step change in the harsh-environment capability of electronics, and improvements in energy efficiency that transform the capability of processors for edge computing. Edge computing, where processing takes place at the edge of the network, often includes applications that exhibit long idle times, with low-throughput bursts of activity triggered by sensing events. Energy conservation is at a premium, as power sources are often batteries, or scavenged energy. This type of characteristic performance is ideal for nanomechanical processors as they have zero standby power, and memory can be placed next to logic on the same chip. This innovation significantly reduces the energy consumption while simultaneously improving performance in computing by drastically reducing off-chip memory accesses. Such "in-memory computing" has long been seen as a way of eliminating the memory communication bottleneck, a fundamental issue in computer architecture, but is technologically infeasible in traditional solid-state transistor manufacturing processes.

Further, the unique capabilities of our nanomechanical switches allow many more connections between switches than is traditionally possible, resulting in much more efficient mapping of designs onto a reprogrammable processor (field-programmable gate array or FPGA). The in-memory computing and extra routing links can be particularly beneficial for implementing simple artificial neural networks (ANN) with drastically reduced energy consumption. The wide set of application classes that can benefit from the technological advancements planned in ZeroAMP has the potential to provide important societal benefits, such as advancing initiatives to reduce dependency on fossil fuels and unlocking the full power of the IoT.

Partners involved in ZeroAMP

Microchip Technology	Monmouthshire, UK
X-FAB MEMS Foundry GmbH	Erfurt, Germany
Gesellschaft für Angewandte Mikro- und Optoelektronik mbH	Aachen, Germany
University of Bristol	Bristol, UK
KTH Royal Institute of Technology	Stockholm, Sweden
Swiss Centre for Electronics and Microtechnology SA	Neuchâtel, Switzerland
SCIPROM Sàrl	Saint-Sulpice, Switzerland

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