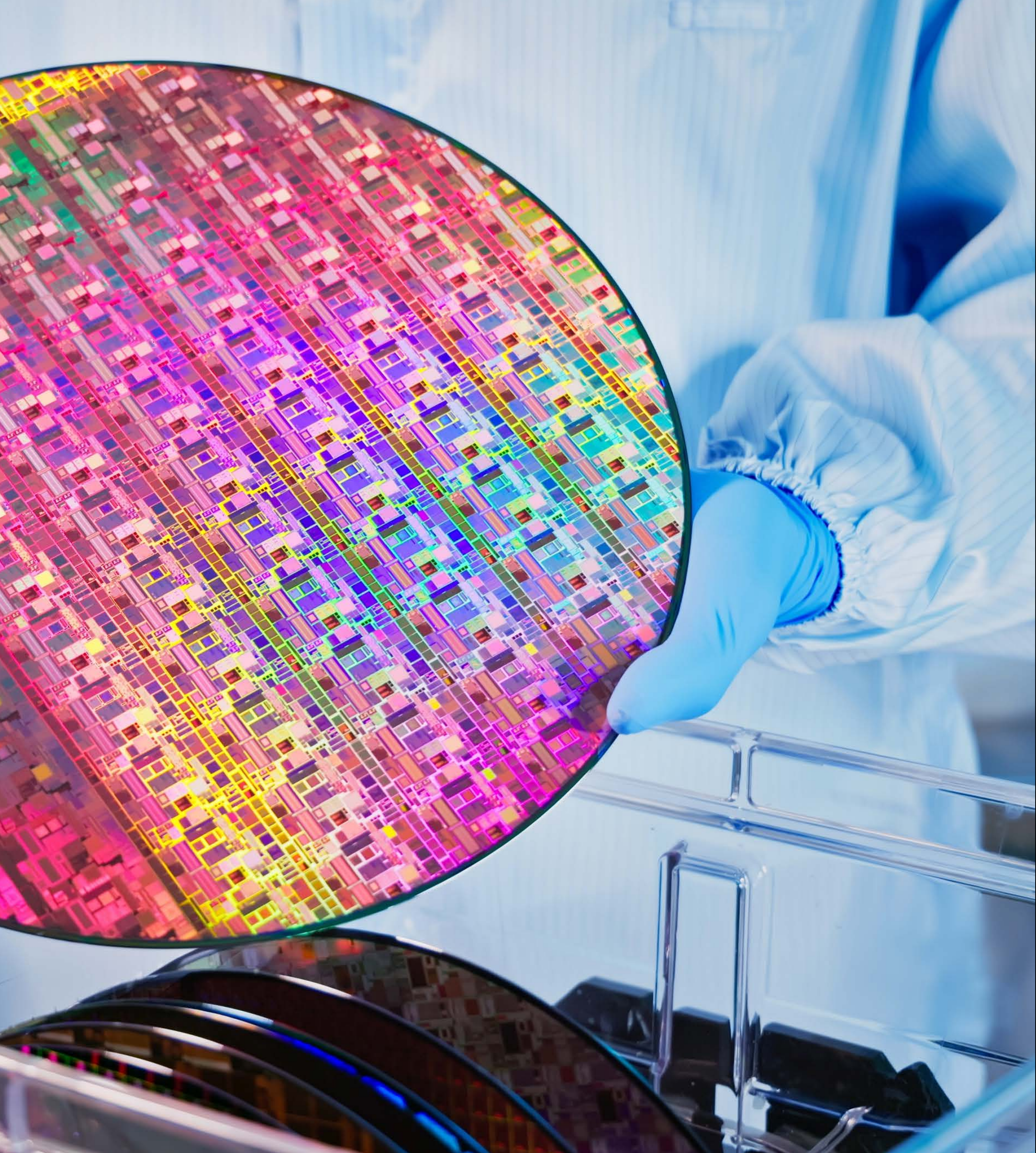
Centre for Electronics Frontiers

Institute for Integrated Micro and Nano Systems
School of Engineering

THE UNIVERSITY of EDINBURGH



Centre for Electronics Frontiers

Institute for Integrated Micro and Nano Systems
School of Engineering

The Centre for Electronics Frontiers brings together diverse expertise ranging from materials science and electronic devices to circuits and systems for transforming modern society through technology.

Our ambition is to push the frontiers of electronics through emerging nanotechnologies, disrupting current ways of thinking by innovating advanced nano/bio-sensors, safe and efficient energy storage solutions and novel Hardware for AI.

We are driven by our vision for building a Resilient World, where the integrity of key infrastructure can be monitored reliably and in real-time. A Healthier World, where bioelectronic and implantable devices can process data intelligently and control biological functions autonomously in a safe and targeted fashion. And a Connected World, where embedded electronic systems can communicate efficiently and effectively, enhancing our quality of life by enabling new services through ubiquitous IoT connectivity.

All of our work is developed by talented researchers in our state-of-art nanofabrication and characterisation facilities and is permeated by an ethos of responsible innovation towards users, their safety, the privacy of their data and the use of natural resources.

The Centre for Electronics Frontiers actively fosters an environment of entrepreneurship and works closely with industry to inspire new innovations in products and applications for making the world a better place.

cef.eng.ed.ac.uk

Welcome to the Centre for Electronics Frontiers

I am delighted to share this inspiring insight into CEF's activities. Across the School of Engineering we are proud of our people and their expertise and this report showcases the vibrant and talented community that is CEF, in the best possible way. We encourage you to engage with us and find out more about how we can all work together to inspire new research developments and innovations in products and applications for creating a better future through engineering.

Guangzhao Mao
HEAD, SCHOOL OF ENGINEERING

In my role as Director of the Centre for Electronics Frontiers, I am delighted to present this insight into who we are and what we do, and to showcase the quality of our facilities that enable the creation of impactful research. Our interdisciplinary team fuses expertise across materials science, electronics and AI for advancing semiconductor devices, low-power AI chips, and bio-interfacing systems, transforming modern society for the better.

Themis Prodromakis
REGIUS CHAIR OF ENGINEERING,
CEF DIRECTOR

MEET OUR VIBRANT

COMMUNITY

Our world-leading centre is a hive of activity with over 50 researchers working on cutting-edge research to provide innovative solutions for real life problems. We enjoy being in (and out!) of the office and labs.

Enjoying the outdoors at Firbush Centre, Perthshire, Scotland

Happy to be at MEMRISYS 2024 in Seoul

Enjoying the Scottish weather at Killin

At work in our labs in Murchison House, the King's Buildings

Celebrating a PhD viva success

Taking in the scenery on the CEF Firbush retreat

Birthday celebrations in CEF

Team work on Loch Tay

Practising our table tennis skills

Celebrating Chinese New Year with the Engineering Graduate Society

Hearing about each other's research and cultures in our CEF chats

Happy New Year from all in CEF!

Relaxing over a game of Dungeons and Dragons

APRIL AI Hub members gather for the first annual summit dinner

Sharing a cake over coffee in the office

Enjoying food from all our countries at our end of term gathering

Sharing our enthusiasm for Engineering in our outreach activities

Getting out and about on the hills

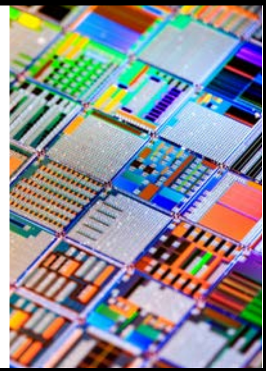
LEARN ABOUT OUR

RESEARCH THEMES

The Centre for Electronics Frontiers looks at some of the biggest challenges facing the world today and attempts to solve them using our exceptional knowledge and facilities. We have key strategic relationships with many industrial partners, government agencies as well as with numerous universities across the globe that allow us to maximise the impact of our work.

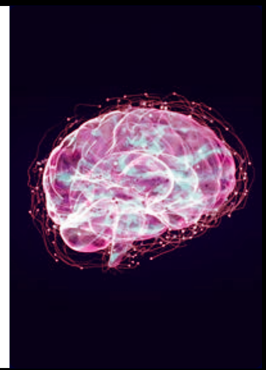
01 AI hardware

Artificial Intelligence (AI) is revolutionising our lives through applications in various domains such as social media, healthcare, automotive, robotics, security, and defence. In turn, this augments the AI model landscape complexity that is primarily driven by Large Language Models (LLMs) and their ever-evolving Transformer architecture, as well as simpler architectures such as Convolutional Neural Networks (CNNs). In both cases, any improvements in efficiency are quickly swallowed by a push to apply them to ever larger input datasets (larger input images, longer context windows, etc.). CEF is addressing this strategically important issue by designing novel AI Computing Architectures that radically change AI data flows or even their formats. Our software-hardware "data flow co-optimisation" actively takes the movement and interaction of data into account, resulting in AI hardware solutions that can significantly increase both speed and power efficiency.



02 Neuromorphic computing

Ever since the 1940's computing has relied on separable computing and memory chips; the Von Neumann architecture. However, AI workloads are extremely memory-intensive. The serial link between processors and memory is so overburdened by this that it has a special name: the "Von Neumann bottleneck". CEF researchers are addressing this issue by developing a new class of architectures called "neuromorphic" that enmesh computation and memory in a highly parallel fabric – alike the neurons and synapses in biological brains. The key feature of our neuromorphic designs is that AI workloads can be massively accelerated, and power can drop enormously as data travels shorter distances on average.

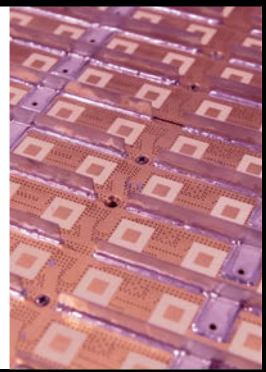


03 Beyond-CMOS technologies

Modern processors comprise billions of transistors, each one a few atoms across. But we have reached the point where further downscaling is both prohibitively expensive and sub-optimally suited to the computational needs of AI. CEF has brought a new era in beyond-CMOS technologies through novel reconfigurable devices based on functional oxides and dielectrics that can be integrated with standard CMOS technologies to sustain innovation in electronics beyond the current semiconductor technology scaling constraints. We are experts in memristor technologies that offer a more scalable, power-efficient and resilient semiconductor fabric to transistors. We have demonstrated that memristors can store multiple bits of information per element, supporting the much-needed shift for running AI from purely digital to analogue computation platforms.

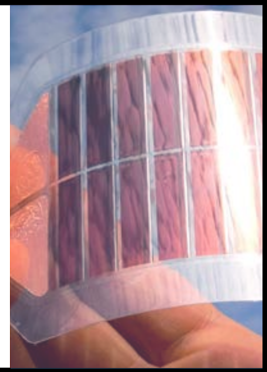
04 Sensor technologies

In CEF we bring together novel sensing materials, high-performance sensor readout circuits, and advanced signal processing to create smart sensors. These sensors are tailored for diverse applications, including medical diagnostics, environmental monitoring, the Internet of Things (IoT), and aerospace technologies. For instance, researchers at CEF have successfully developed cost-effective, real-time protein detection systems that monitor cytokines in vitro, with potential applications expanding into clinical settings. In partnership with industrial stakeholders, our team leverages established manufacturing processes to produce customised sensing topologies and microscale fluidic systems, enhancing our capability to design and fabricate tailor-made sensing solutions for varying needs.



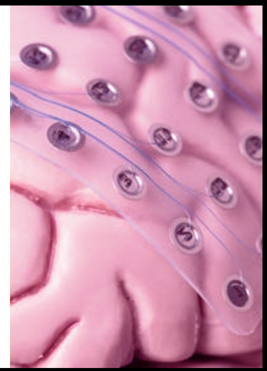
05 Energy harvesting technologies

To mitigate climate change, we are working towards providing scalable and eco-friendly solutions for energy harvesting. The key is the use of organic semiconductors, which have unique optoelectronic properties, require low processing temperatures, and can be simply manufactured through printing methods, enabling large-scale commercialisation. Our research also focuses on a careful consideration of the materials selection in terms of sustainability and upscaling feasibility. We are developing high-efficiency organic solar cells for indoor and outdoor applications and evaluating their long-term stability. Combined with our group's expertise in designing integrated circuits for efficient power-management, CEF can provide full system solutions for a wide range of energy-harvesting technologies.



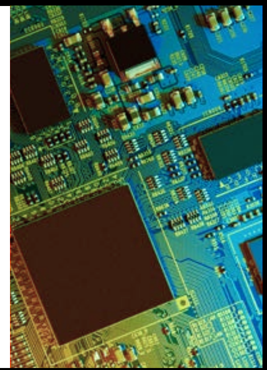
06 Bioelectronics

Researchers in CEF are developing novel devices, sensors, and microchips that can interact with biological systems. These include neural interfaces, electrochemical sensing platforms, and wearable systems for health monitoring. Leveraging breakthroughs in nanomaterials, nanoelectronics, ultra-low-power circuit design, and integrated microsystems, we have pioneered innovative solutions that can be deployed both in-vitro and in-vivo settings. Our research enables new approaches to interface biology with enhanced precision, versatility, and power efficiency. These advancements are pivotal in developing new methods for studying biological functions and diseases, and they hold significant potential for driving technological innovations in health monitoring and medical treatment.



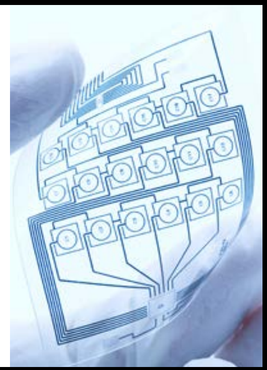
07 Radiation resilient electronics

Modern electronic technologies have progressed to the level that they can nowadays be deployed almost everywhere – including into harsh and inaccessible environments that may even need to operate under high radiation. In CEF we are investigating the effect of radiation in semiconductor technologies and innovating solutions that can be resilient to such effects. To achieve this, we are capitalising on the intrinsic radiation hardness of nano-ionic memristor technologies along with innovative chip designs that are radiation resilient. Our technologies become increasingly relevant to application areas such as space, data centres, healthcare and scientific instrumentation as well as the defence and energy sectors, contributing to enhancing the reliability of electronic systems and unlocking new technological capability.



08 Flexible electronics

Flexible electronics bring cutting-edge technology to bendable and stretchable substrates, enabling smart wearables, flexible displays, and artificial skin. Our team is advancing this field by harnessing metal oxides, which offer transparency, low power consumption, photosensitivity, and mechanical flexibility. These materials help to enhance the performance of flexible devices, allowing their deployment into new formats and environments. CEF benefits from our access to SMC's state-of-art prototyping capabilities that allow us to develop scalable and cost-effective technologies that are compatible with flexible substrates in a sustainable fashion.

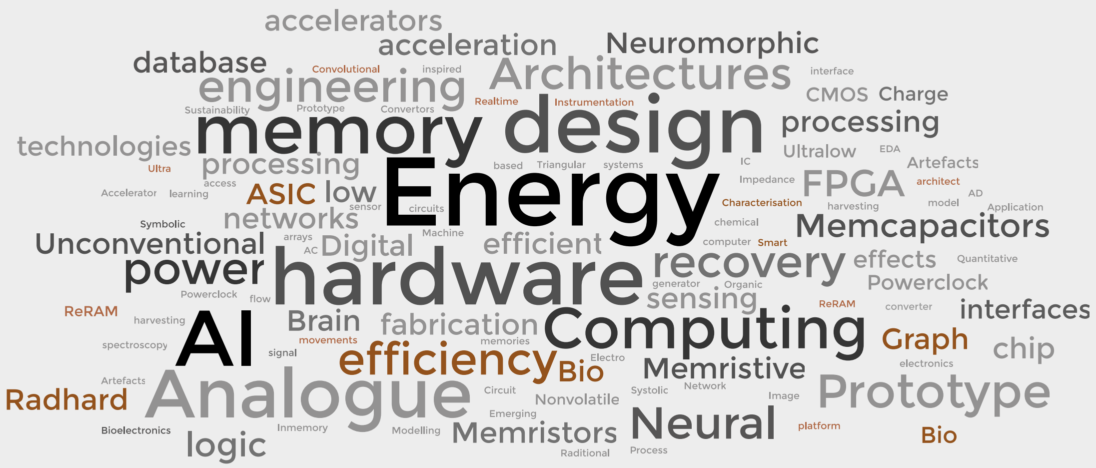


09 Recyclable and sustainable electronics

With an ever-increasing demand for ubiquitous electronics, reducing e-waste and designing products with a clear end-of life is of primary importance. CEF researchers are working on developing electronics that can be recycled, with decreased CO_2 equivalent emissions, and overall eliminate the use of scarce elements. We are focusing on improving the sustainability of modern electronics by looking into their entire lifecycle, from raw materials to the end-of-life. We combine advanced experimental techniques along with machine learning models, and life cycle analysis for accelerating the identification of new materials and procedures that unlock a new generation of sustainable electronics.

GET TO KNOW

WHO WE ARE



Themis Prodromakis

Regius Chair of Engineering

Themis's work is inspired by nature's efficiency in processing information under constrained resources and environments. He develops energy-efficient AI hardware solutions through innovating novel semiconductor technologies and neuromorphic computing architectures. He is particularly excited by applying his research across disciplines such as semiconductors for AI, AI for semiconductors and bio-inspired technologies in healthcare.

Bio inspired technologies | Memristors | Neuromorphic compute

Neuromorphic computing

Shiwei Wang

Reader in Integrated Neuroelectronics

Shiwei researches on analogue and mixed signal integrated circuits which have applications in areas such as low-power sensing, biomedical devices, and IoT. His research concentrates on the development of integrated circuit chips that can perform demanding tasks such as reliable acquisitions of physiological signals free of real-world artifacts, but also have ultra-low power consumption, enabling their deployment in energy-constrained environments.

Bioelectronics | Smart sensing | Neural interfaces

Bioelectronics

Alex Serb

Reader in Unconventional AI Hardware Technologies

Alex's research interests span circuit and system design and AI, with a particular focus on emerging technologies. Alex works on hardware as well as at the device level – and including the entire stack spread within. His research seeks to dramatically decrease the amount of energy required to perform useful computation and accelerate the speed at which it can be performed in practice.

In memory computing | AI accelerators | Charge recovery logic

AI Hardware

Julianna Panidi

Chancellor's Fellow

Julianna is developing methods to manufacture high-performance, eco-friendly, and printable electronics for energy harvesting and sensing applications. The primary focus is given to identifying greener materials and solvents for electronics development without compromising their efficiency. Finally, another area of interest is electronics recycling with simple methods to reuse or recycle the products.

Organic electronics | Sustainability | Energy harvesting

Energy harvesting technologies

Shady Agwa

Senior Research Fellow

Shady researches on bridging the gap between emerging technologies and the ever-increasing performance demands of AI models, especially Convolutional Neural Networks (CNNs) and Large Language Models (LLMs). The ultimate goal is to Combine the Exact computing capabilities of Conventional AI Specific Integrated Circuits and Systems (AISICS) with the Approximate computing capabilities of Unconventional AISICS to develop Scalable Heterogeneous AI (SHAI) Computing Systems.

AI | Computing Systems | VLSI | Computer Architectures

AI Hardware

Spyros Stathopoulos

Principal Experimental Officer

Spyros has a background in semiconductor physics and currently works on the realisation, fabrication and characterisation of novel devices based on semiconductors and thin films. His main research interest is around heterogeneous integration of thin films and semiconductors to enable applications in novel memories and beyond-CMOS electronics. He is also responsible for developing new fabrication and testing processes that cut across the different CEF areas of research.

Thin films | Heterogeneous integration | Semiconductor processing

Beyond-CMOS technologies

Our expertise and skills cover a broad spectrum and we enjoy both the synergies and the differences.
Find out more about who we are and what we do.

Cristian Sestito

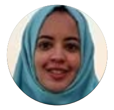
Research Fellow in AI for Circuits and Systems Design automation

Cristian is investigating how to implement energy-efficient architectures for AI in hardware, focusing on systolic arrays for Convolutional Neural Networks to tackle the energy cost of moving data between memory and computing core through local data reuse. Cristian's work also focuses on how to exploit AI, especially Large-Language Models (LLMs), to automate circuits and systems design in commercial tools.

Systolic array | Human-AI circuit co-design | AI accelerators

AI Hardware

Razan Aboljadayel



Research Associate in Thin Film Devices for Magnetic and Spintronics

Razan's research focuses on magnetic thin films and devices for spintronic applications. Building on her foundation in fundamental physics research in magnetic spintronics, Razan is now working on developing novel devices and memory technologies for AI hardware applications. This involves developing thin film processes, fabricating innovative spintronic devices and employing a wide range of characterisation tools to optimise performance.

Magnetic thin films | Spintronics

Beyond-CMOS technologies

Atish Dixit

Research Fellow in AI for Materials Discovery

Atish's research combines machine learning, applied mathematics, and computational simulations to explore innovative ways of designing and optimising engineering designs. He has focused on building generative AI to solve engineering problems in the areas of petroleum engineering and multi-agent robotic systems. Atish aims to develop AI-driven frameworks that improve efficiency and uncover new possibilities for material innovation.

AI-assisted material discovery | Computational simulations

AI Hardware

Chandrabhan Kushwah

Research Associate in AI for Electron Device Design

Chandrabhan is working on AI Electron device design to identify key features of components or devices by analysing large datasets from simulations, experiments, or historical data. Machine learning models can extract patterns that characterize the devices, such as performance metrics, material properties, and design features. These characteristics can then be compared across different devices to identify similarities and differences, which helps in decision-making, optimisation, and benchmarking.

AI in electronics device design | AI accelerator

Neuromorphic computing

Georgios Papandroulidakis

Research Associate

Georgios's research involves the integration of emerging memory technologies alongside conventional electronics for the implementation of memory-centric accelerator systems. These systems are aimed at accelerating specific computing functions that are considered cornerstone functions for important algorithms, such as machine learning related algorithms. The benefits of extreme edge applications are seen in energy efficiency and real-time response of the application.

Memory-Centric Accelerator Design | Neuro inspired systems

AI Hardware

Ben Rowlinson

Research Associate in AI for Device Materials Discovery

Ben's research focuses on exploring new, non-silicon-based materials for electronic devices and circuits. Across the periodic table, there are millions of combinations of elements that could offer improved characteristics, lower environmental impact or properties yet to be discovered. Ben's dual experimental and computational approach leverages machine learning techniques on real, measured data.

Electronic materials | Data-driven

Beyond-CMOS technologies

Chris Giotis

Research Associate in Graph Database Accelerators

Chris's work focuses on building ATLAS, an AI chip that physically stores the relationships between complex datasets and enables the discovery of hidden connections between data in milliseconds. ATLAS aims to aid digital payments identify fraud 10x faster and more accurately, potentially saving up to $400B in the next decade. Chris is co-investigator in a Scottish Enterprise High Growth Spinout Programme that will build the first demonstrator of ATLAS and bring it one step closer to the market.

Machine learning | Hardware

AI Hardware

Sachin Maheshwari

Research Associate

The generative AI model consumes power in 100's of kW range, as compared to the human brain that uses around 20W of power. Sachin's research aim is to minimise this gap by using unconventional computing of charge recycling techniques. The research has many potential benefits in edge-computing applications such as autonomous systems and camera surveillance.

Adiabatic Logic | Energy Recovery Logic | Neural Network

Neuromorphic computing

WHO WE ARE

Patrick Foster
Research Associate

Patrick designs the hardware necessary for testing and characterising the group's many projects. The experimental nature of such research projects often requires that custom PCBs be designed to interface the new ICs with existing instrumentation, or in some cases, that entirely new and highly specific instruments be designed.

Instrumentation engineering | Hardware engineering

Sensor technologies

Yihan Pan
Research Associate in Mixed-Signal Integrated Circuit Design

Yihan researches advancing energy-efficient AI hardware through the design of novel architectures that leverage unconventional computation methods. A key aspect of Yihan's work lies in both the architecture itself and the development of hardware-friendly data representations that align seamlessly with it. Together, these innovations pave the way for enhanced computational efficiency while upholding a high standard of accuracy.

Energy-Efficient AI Hardware | Unconventional Computing Architectures

AI Hardware

Himadri Singh Raghav
Research Associate in Mixed Signal Integrated Circuit Design

Himadri's research is in the area of energy efficient implementation of VLSI circuits. In particular, circuit techniques that can deliver energy savings over the conventional power-hungry CMOS logic. The potential benefits of the research could be avoidance of batteries in remote IoT enabled sensor nodes deployment for various applications such as soil management, railway tracks monitoring.

Energy efficiency and recovery | Power-clock generator

Neuromorphic computing

Santhosh Sivasubramani
Research Fellow in AI for Electronic systems modelling

Santhosh's research focuses on developing advanced AI tools to model system behaviour, device characteristics, and reliability for next-generation computing hardware. He is working on creating digital twins to predict device performance, optimise their durability, and reduce computational costs. Using computational facilities, Santhosh aims to bridge the gap between device-level modelling and real-world performance, ensuring reliable and sustainable technology for future applications.

AI for Hardware | Beyond CMOS Logical Devices

Beyond-CMOS technologies

Javad Heydarian
Research Associate

Javad's research focuses on FPGA prototyping and AI hardware accelerators for graph and vector databases. His work aims to enhance computational efficiency and performance in data-intensive applications by leveraging reconfigurable hardware solutions. This research contributes to the development of specialised hardware architectures tailored for AI-driven database processing.

AI hardware accelerator | Graph/vector databases | FPGA

AI Hardware

Joydeep Ghosh
Research Associate in AI for Electronic Systems Modelling

Joydeep's research focuses on nano-scaled CMOS device (e.g. FinFET, GAA-FET, nanosheet) simulations, different modelling techniques in beyond CMOS technology (e.g., Spintronics), electronic transport simulations, HEMT device simulations for RF applications. He is also interested in applications of different machine learning methodologies in electronic devices and systems to enhance their performance.

CMOS | HEMT | Machine learning

Beyond-CMOS technologies

Pratibha Verma
Research Associate in AI for Electronic Systems Modelling

Pratibha is working on the automisation of circuit design using AI driven modelling tools. Pratibha will be designing integrated circuits using automated tools that the whole APRIL AI Hub team will design. This research aims to reduce the time and complexity of circuit design, in an energy efficient manner.

Circuit design | AI driven modelling

Beyond-CMOS technologies

Danial Khan
Research Associate in Mixed-Signal Integrated Circuit Design

Danial's research focuses on analogue and mixed integrated circuits including energy harvesting technologies, and power management integrated circuits (PMICs) such as BGR, LDO, and DC-to-DC converters for IoT applications. His work aims to develop efficient power solutions that enable the long-term operation of IoT devices in remote environments without frequent battery recharging.

Energy Harvesting | PMIC

Energy harvesting technologies

Alexandros Keros
Research Fellow in AI for Electron Device Materials Discovery

Alexandros works on exploring the interplay of structure and function by employing topology, geometry, and machine learning methods to discover novel materials for electron devices. Achieving this entails understanding complex dynamical systems, efficiently producing accurate physical models and simulations, and concisely modelling the resulting structures.

Topological Data Analysis | Geometric Deep Learning

AI Hardware

Andreas Tsiamis
Experimental Officer in Nanofabrication

Andreas's research focuses on the development of electrically and optically controlled metal-oxide memristive devices, where he is also exploring routes for their integration with CMOS technologies. For his work he is developing novel micro and nano fabrication processes, both at wafer and chip level. Andreas's work enables a wide range of applications across the Centre for Electronics Frontiers to move forward.

Emerging memristor devices | CMOS integration

Beyond-CMOS technologies

Hannah Levene
Thin Film Process Engineer

Hannah works on the process development for thin film deposition and material characterisation. Her expertise in microfabrication and metrology supports research within CEF. Hannah is the main contact for key pieces of equipment including ALD (Atomic Layer Deposition), XPS (X-ray photoelectron spectroscopy) and AFM (Atomic Force Microscopy) which are used by researchers in CEF, across the University and provide services for industry.

Material science | Microfabrication | Surface characterisation

Flexible electronics

Mike Smart
Software Engineer for AI accelerators

Mike focuses on exploring novel, energy-efficient, electronic circuits. Increasing power requirements from applications, such as AI, are demanding solutions to tackle their environmental impact and limitations on electronic device usage. Mike's research provides engineers with validated methods to robustly map between power-hungry software applications and emerging low-power hardware.

AI hardware | Neuromorphic computing

AI Hardware

Ahmed Abdelmaksoud
PhD student

Ahmed works on designing a high-performance, energy-efficient hardware accelerator for transformers by leveraging spatial and specialised architectures with emphasis on utilising the potential of systolic architectures to mitigate memory bottlenecks and enable energy-efficient computation for the massive workloads of transformer models. He explores optimisation opportunities within transformer models, emphasising sparsity and adaptive quantisation/processing techniques for edge computing.

Energy efficiency | Transformers Acceleration

AI Hardware

Grahame Reynolds
PhD student

Grahame's research focuses on designing novel Compute-In-Memory architectures using novel devices, to address the von Neumann bottleneck. Such architectures depart from conventional schemes by consolidating memory and processing operations into a single structure and are similar in principle to the operation of the human brain.

In-Memory Computation | Neuromorphic | Neural Sensing

Bioelectronics

Deepika Yadav
PhD student

Deepika works on memcapacitive and ferroelectric behaviour in advanced materials, combining device fabrication and material characterisation, aiming to develop innovative solutions for next-generation memory and computing technologies that leverage the complementary advantages of memcapacitive and ferroelectric functionalities. Deepika has started exploring the ferroelectric properties of doped hafnium oxide to induce polarisation.

Memcapacitors | Ferroelectricity

Beyond-CMOS technologies

Dongxu Guo
PhD student

Dongxu's research is on the development of innovative bioinspired auditory signal encoders by integrating volatile memristors and level-crossing analogue-to-digital converters. His work explores how advanced ADC architectures and memristive devices can enhance energy efficiency and scalability. Dongxu aims to develop practical solutions for auditory signal processing in neural interfaces and other bio-inspired electronics applications.

Neuromorphic | Analogue circuit design

Neuromorphic computing

Yanjun Yang
PhD student

Yanjun focuses on developing symbolic AI hardware accelerators based on graph databases, aiming to enhance computational performance and efficiency. This interdisciplinary work combines elements of computing architecture, near-memory computing, and knowledge representation. His research aims to revolutionise the computational backbone of advanced AI systems by introducing hardware symbolic accelerators that are both faster and more energy-efficient.

Symbolic AI | Hardware accelerator

AI Hardware

Guoyang Huang
PhD student

Guoyang researches the development of a Process Design Kit (PDK) for memristive devices, aimed at creating a unified model that encompasses behavioural features such as resistive switching, noise, resistive state boundaries, temperature-dependent drift, volatility. This developed PDK for memristive devices will support more reliable and accurate simulations and facilitate the design and implementation of hybrid CMOS/memristor circuits.

PDK for memristive devices | AI for EDA

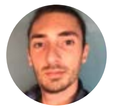
Beyond-CMOS technologies

Caterina Sbandati
PhD student

Caterina works on a brain-machine interface project for implantable neuroprosthetics, utilising memristors to efficiently process and interpret neural signals. Caterina's research aims to enhance the reliability and efficiency of smart neural implants, potentially revolutionising treatments for chronic illnesses. Her work focuses on translating neuroscientific insights and leveraging technological advancements, such as low-power nanodevices, into practical solutions.

Memristive sensing | Brain computing

Bioelectronics



Alin Panca
PhD student

Alin's work is on the development of a 1Transistor-1Memristor structure using compatible metal oxide materials for high-performance computing. This emerging platform is designed to operate at low processing temperatures (<400°C), allowing integration onto flexible substrates and expanding its applicability to diverse technological fields. The benefits of Alin's research lie in advancing traditional computing technology by enhancing performance and efficiency.

Process engineering | Thin film transistors

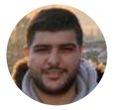
Flexible electronics

Khaled Humood
PhD student

Khaled's research involves investigating emerging non-conventional computing paradigms, particularly in-memory computing architectures. To advance this field, SPIKA, a state-of-the-art RRAM-based in-memory computing engine designed to accelerate ML applications, has been developed. Resistive Random Access Memory technology is leveraged to store weights due to its low read voltage, multi-state capability per cell, and dense structure, achieving unprecedented power efficiency.

AI Accelerators | In-Memory Computing

AI Hardware



Ahmet Cirakoglu
PhD student

Ahmet's research is leveraging the inherent radiation tolerant properties of memristors to build RRAM (Resistive Random Access Memory) arrays that are less affected by various radiation damage mechanisms compared to standard, commercially available and matured memory technologies built by standard, silicon-based transistors. Ahmet's work aims to demonstrate that RRAM-based accelerators can also be used in harsh environments, such as space.

Resistive Random Access Memory (RRAM)

Radiation resilient electronics

Shan-Hao Sung
PhD student

The main topic of Shan-Hao's research is designing an intelligent camera. As artificial intelligence develops, intelligent cameras will become a highly demanding product because they can be used in many different life scenarios. The aim is to design an AI camera with the full function of machine vision, with sufficiently complex data to ensure privacy.

Artificial Intelligence | Machine Vision | Analogue IC design

Neuromorphic computing

Xiongfei Jiang
PhD student

Xiongfei's research focuses on implementing a real-time bidirectional neural interface chip that can concurrently record brain activities and stimulate to treat neurological disorders such as epilepsy and Parkinson's disease. By applying algorithms and stimulations, a compact and stable neural interface instrument can be expected in the future to help those living with neurological conditions.

Neural interfaces | Bio-signal recording & processing

Bioelectronics

Lucas Han
PhD student

Lucas's research field is on-chip spike sorting. The focus is on the on-chip spike sorting for scaling up to more channels by improving area and power efficiency while keeping the sorting accuracy. This research can benefit the interpretation of brain activities, thus promoting the advancement of brain-machine interface and brain stimulation therapy.

Neurosignal processing | Digital ASIC

Bioelectronics

Minghui Cui
PhD student

Minghui develops read-out circuits for electrochemical sensing. With the development of nanotechnology, electrochemical sensing of biomolecules provides a convenient detection solution for modern diagnostics. A continuous time (CT) delta-sigma modulator will be used to directly read the input current signal from the electrochemical sensor. The power wasted on the sink current of IDAC can be recycled to power digital circuits or charge a battery.

Sensor technologies | Energy harvesting

Bioelectronics

Xuyang Xia
PhD student

Xuyang researches hardware acceleration of dual vector/graph database (VDB/GDB) retrievals. State-of-the-art retrieval algorithms deploy graph-based solutions, and Xuyang is working on accelerating the algorithm through CEF's associative memory hardware which supports graph operation. Upon successful implementation of the database accelerator system, the aim is to see LLMs equipping this accelerator system for improved speed and quality of response.

Hardware acceleration | Graph database | Network on chip

AI Hardware

Bochen Ye
PhD student

Bochen's research focuses on designing hardware acceleration systems for large-scale AI models using novel architectures, aiming to overcome memory and computational bottlenecks. His work emphasises efficient dataflow, high-performance accelerators and energy-efficient AI systems on digital ASIC chips.

AI accelerator | ASIC | LLM

AI Hardware

LEARN ABOUT OUR

RESEARCH PROJECTS

We are committed to achieving excellence in science and engineering and to ensuring that our research contributes to the well-being of society. This section presents some of our flagship programmes.

APRIL AI Hub

AI Hub for Productive Research & Innovation in Electronics — www.april.ac.uk

Our national consortium funded by UKRI comprises 20 academic institutions and over 30 industrial partners that brings to market AI-based tools to boost productivity across the entire electronics industry supply chain. APRIL is transforming the electronics industry by developing world-leading AI research relevant to the electronics industry, building a strong expandable network that can influence the direction of research, policy and regulation, enabling the adoption of technology into business through the creation of AI tools or translation into new start-ups and generating a strong pipeline of talent that spans AI and electronics. The APRIL Hub will lead the way in AI research, focusing on key areas of the electronics supply chain: Material Discovery; Device Design; Circuit & System Design; Test & Verification; and Modelling. APRIL's development of AI tools will lead to faster, cheaper, greener and overall more power-efficient electronics.

ACAN

Adiabatic Capacitive Artificial Neuron

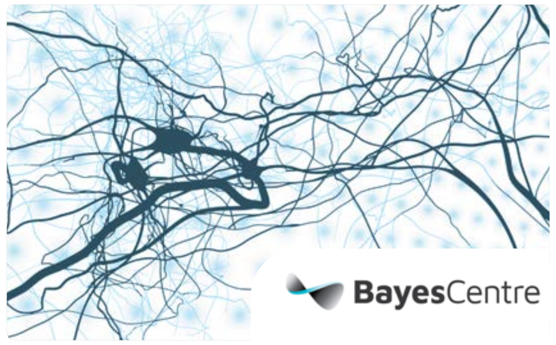
Bigger and more capable AI systems require increasingly more power to operate at full capacity, straining global energy supplies and limiting the democratisation of AI. Project ACAN uses charge recovery to implement AI systems with far higher power efficiency; aiming to lower the power consumption of such systems by a factor of 10x while remaining fully compatible with current, tried and tested CMOS manufacturing technology. The approach is particularly promising when applied on neural networks, where it leverages their parallelism. Our aim is to demonstrate how modular ACAN-type artificial neurons can be implemented and combined together into practically usable networks of virtually any shape and size. The ability to build tailor-made, ultra-low power artificial neural networks, such as project ACAN offers, is critically important in areas where both cost and power budgets are severely constrained with applications in low-power, long-lasting implants for medical use and microchips for autonomous drones as prime examples of impact. This work is funded by DSTL.

FORTE

Functional-oxide Reconfigurable Technologies — www.forte.ac.uk

The EPSRC-funded programme grant FORTE brings together world-leading expertise across the University of Edinburgh, Imperial College London and the University of Manchester with the ambition to transform ICT through delivering highly scalable, resilient, power efficient and affordable reconfigurable electronic systems. Our approach is targeted on rebalancing the UK electronics remit from a 'more' to 'beyond Moore' era via developing functional oxide-based memristor-based architectures and integrating these with CMOS for boosting conventional electronics capabilities. This will allow our society to efficiently expand the operational envelope of electronics, enabling the use of electronics in inaccessible environments as well as reusing or re-purposing electronics affordably.

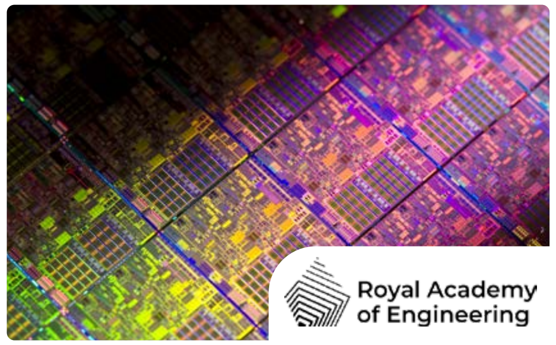
Bayes Innovation Fellowship



Shiwei Wang is the holder of a Bayes Innovation Fellowship, awarded to academics with a compelling research translation ambition. Shiwei focuses on innovating novel chip technologies that interface with the brain. A short-term target is to change the limitation that no technologies today allow reliable neural recording and stimulation in a concurrent manner (i.e., read from and write to the brain simultaneously). This is an urgent unmet need because testing and fine-tuning of devices intended to treat or diagnose neurological conditions are difficult without knowing the brain's immediate responses to stimuli. Shiwei's team has tackled this challenge using a novel integrated circuit chip that can readout tiny neural signals with high fidelity even at the presence of large stimulation artifacts. The technology has been validated both in-vitro and in-vivo and through the fellowship he is translating this innovation into commercial products. The immediate impact is to allow more reliable data from pre-clinical testing, accelerating the neurological healthcare innovation.

RAEng Chair in Emerging Technologies

AI MeTLLE - Memristive Technologies for Lifelong Learning Embedded AI Hardware



The Royal Academy of Engineering's Chair in Emerging Technologies scheme aims to identify global research visionaries and provide them with long term support to lead on developing emerging technology areas with high potential to deliver economic and social benefit to the UK. In 2020 Themis Prodromakis was awarded a Chair in Emerging Technologies for his work on Memristive Technologies for Lifelong Learning Embedded AI Hardware, using innovations in nanotechnology to create a new electronic fabric that merges memory with computing power while maintaining extreme power efficiency – alike the human brain. The research, using memristors or memory chips based on transition metal-oxides, focuses on enabling electronic systems to sense, recognise, learn and reason, with the goal of embedding artificial intelligence.

AEGIS

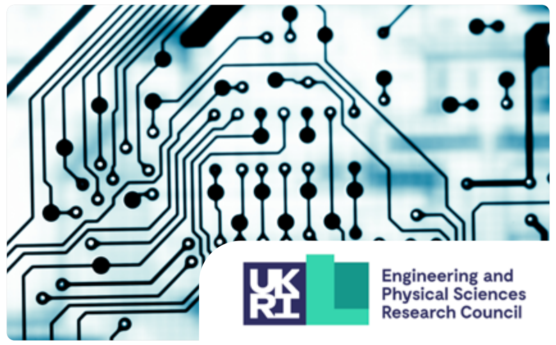
Artificial intelligence Enabled Guide for Investment Strategies

AI is a rapidly evolving and highly disruptive technology being implemented within the financial services industry, for example in dealing with an enormous volume of financial transactions and decisions with wide-reaching implications in the real world. There is potential for catastrophic incidents if the risks associated with implementing AI in this field are not adequately managed. Project AEGIS uses generative AI to carry out trading or insuring activity in a high-quality, trustworthy and self-correcting manner, and to understand what the limits of this approach are. We are developing software that can perform important trading/insuring tasks autonomously and can be equipped with a rudimentary set of circuit-breakers. This will be accompanied by a set of benchmark tests illustrating how the software can be expected to perform under various market conditions and outlining the challenge and opportunity space in this technology. Thus, AEGIS seeks to set the foundations for what we fully expect will become an ever more elaborate system, eventually "earning the trust" to work side-by-side with a human in the financial industry, as per our vision.

RESEARCH PROJECTS

We are committed to achieving excellence in science and engineering and to ensuring that our research contributes to the well-being of society. This section presents some of our flagship programmes.

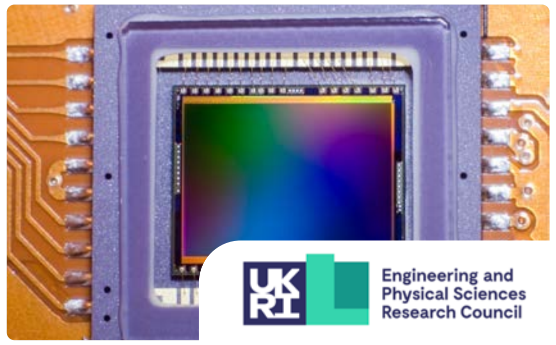
The David Clarke Fellowship



This joint Energy Technologies Institute (ETI) and EPSRC fellowship award is held by Julianna Panidi whose research focus is on developing methods for improving the sustainability of solution-processed solar cells and using them as light-powering sources. Attention is given to the material selection and processing methods for the development of organic solar cells without compromising their power conversion efficiency. Another important aspect for Julianna's focus is their stability, which will be evaluated in both indoor and outdoor settings. By combining electrical and morphological characterisation, Julianna aims to understand the main degradation mechanisms, which will then support future research developments.

ProSensing

Low-Power, High-Speed, Adaptable Processing-In-Sensing Capability

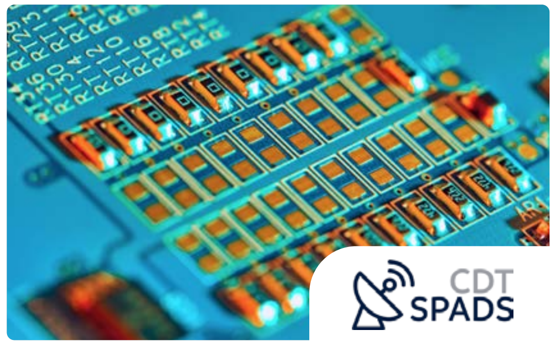


ProSensing aims to define a novel approach to embed intelligence locally, enabling training at the edge by developing novel in-sensing processing elements (enabling electronic and photonic control) that will be combined with tinyML technologies. The development of an in-sensor processing architecture using emerging devices (RRAMs) for image classification is proposed, with the capability of being used in various domains including light, RF, IR, and gas. This will significantly reduce the data transmission penalty, where only relevant features are transmitted to the near-sensor high-level processing and tinyML layers. Furthermore, we aim to eliminate the analogue-to-digital interfacing complexity by processing the extracted features as analogue vectors. RRAM-based Analogue Content-Addressable Memories (ACAMs) will capture pretrained analogue templates to act as a near-sensor classifier. This is a collaborative programme with the Universities of Strathclyde and Nottingham Trent.

SPADS

EPSRC and MoD Centre for Doctoral Training in Sensing, Processing, and AI for Defence and Security

spads.eng.ed.ac.uk



This University of Edinburgh led Centre for Doctoral Training Programme focuses on generation-after-next technologies for information processing in defence and security, spanning the entire range from hardware development to algorithmic AI development. SPADS is training the next generation of highly professional defence scientists, including engineers, computer scientists, and mathematicians, capable of leading developments in cutting-edge and generation-after-next technologies in information and communication technology that are poised to transform not only the world of defence and security, but also broader civilian society. This will be approached by underpinning interconnected technology and sensing modalities working across multiple sensing domains, leveraging advances in autonomy, embedded systems, and AI across both software, algorithms and hardware. Alex Serb is a Co-Director on this CDT, leading on Novel computing and Beyond-CMOS hardware.

EXPERIENCE

A DAY IN A ROLE

in the Centre for Electronics Frontiers

Our skills and expertise range from those studying for their PhD with us across the expertise of our Experimental Officers, Professional Services staff and Academic experts. We enjoy the fast pace of our co-located community, where we interact with and learn from each other.

Shiwei Wang
Reader in Integrated Neuroelectronics

9 am
Visited Edinburgh Neuroscience and did an experiment at George Square testing facility on animal disease

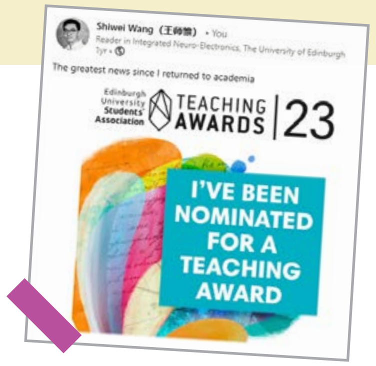
10 am
Lab time with students

11 am
Brainstorming about chip testing on mouse experiments

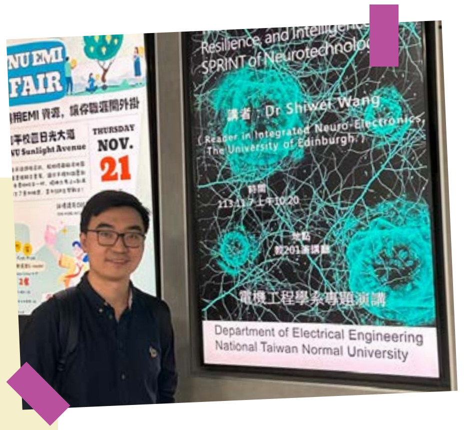
12 noon
Discussion on possible NERC proposal

2 pm
Prep for talk to IEEE Student Branch Edinburgh as part of their Biomedical Engineering Lecture Series

2:30 pm
New course development



3:30 pm
Visited Taiwan couple of months ago and now writing up my report



Anastasia Eleftheriou
APRIL AI Hub Manager

9 am
Prioritising APRIL team's tasks and deliverables

10 am
Talk with APRIL Pillar leads. Co-ordinate with research pillar leads to ensure progress on key initiatives

11 am
Take delivery of promotional materials, including our APRIL book, for upcoming APRIL AI Summit

12 noon
Meet with colleagues in the School to discuss how to apply for Digital Badge for our summer internship students

1 pm
Go along to lunchtime CEF chat to update colleagues on APRIL activities

2 pm
Teams call with EPSRC colleagues to discuss up and coming reporting deadline

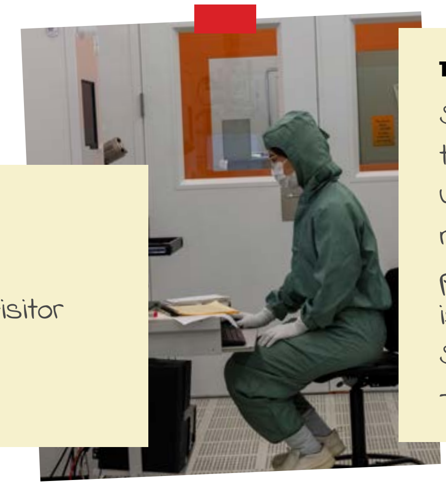
3 pm
Coffee with APRIL researchers and plan for induction of new researcher arriving shortly

3.30 pm
Proofreading APRIL newsletter

EXPERIENCE

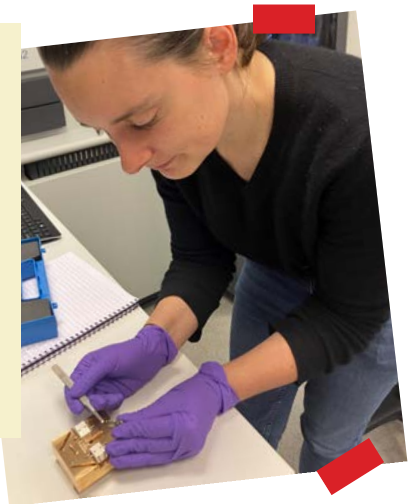
A DAY IN THE ROLE

in the Centre for Electronics Frontiers



9.30 am
Industrial visitor planning

11 am
SMC has many users throughout the University. Need to understand their experimental needs. The XPS (X-ray photoelectron spectroscopy) is currently being used by the School of Chemistry academics - liaise on this



9 am
Cleanroom users meet every morning in order to update all users on the status of facilities and equipment. The ALD (Atomic Layer Deposition) tool has an issue - need to liaise with the School technicians

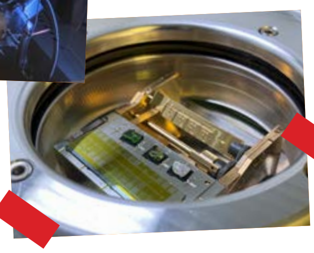
Hannah Levene
Thin Film Process Engineer

12 noon
Undertaking some data analysis on the pc for the XPS. An external industrial contact needs to understand what is in the substance being sampled

4:30 pm
Getting samples loaded into the XPS to pump overnight and setting up a measurement

1 pm
Meeting with a colleague from EI (Edinburgh Innovations) for details on commercial contacts

3.30 pm
Some time for fabrication



3 pm
Running monthly calibration checks on the XPS checking that there is no degradation of the anode which produces the x-rays

2 pm
Researchers from CEF come over to work with the ALD equipment and help me write a new recipe for it, creating a mix of different materials

10:30 am
Organise and facilitate the CEF chats, with Guoyang - looking for the next potential speakers

10 am
Working on integrated circuit design for the upcoming tapeout

11:30 am
Guiding Masters students via weekly meeting on circuit design

Yihan Pan
Research Associate
in Mixed-Signal Integrated Circuit Design

9 am
Meeting all FORTE designers to check on progress on our latest tapeout

4 pm
Yanjun PhD support

2 pm
Scheduling some time for circuit testing for after tapeout and optimise test plans with the Arc2

3 pm
Research chat with Shady on computer architecture issue

LEARN ABOUT OUR

IMPACT

CEF actively fosters an environment of entrepreneurship and works closely with industry to inspire new innovations in products and applications for making the world a better place. We enjoy developing and being involved in outreach activities where we can inspire and enthuse the next generation of engineers.

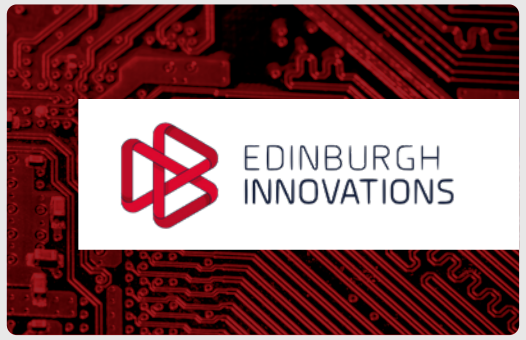
01 Entrepreneurship

Forming strong, strategic relationships and sharing our ideas with industry is fundamental to our success. Over the past decade, CEF has forged close relationships with >100 global companies across our programmes. We are always open to new and thought-provoking collaborations where a combination of expertise may be mutually beneficial and inspire new innovations in products and applications.

Developing Intellectual Property

Our group maintains a significant IP portfolio via Edinburgh Innovations (EI), the University of Edinburgh's commercialisation arm. We work closely with our colleagues in EI, who guide us on how best to create impact and commercialise our research, bearing in mind the type and stage of our technologies, the market demand, and our ambitions.

edinburgh-innovations.ed.ac.uk



EVA: The Edinburgh Venture Builder in AI Hardware

To accelerate the commercialisation of our research in CEF in an efficient, scalable and targeted manner, we have established the world's first Venture builder for sustainable AI Hardware. EVA drives success through a unique combination of a distinctive venture builder model applied to a portfolio of novel semiconductor technologies. This approach facilitates the creation of multiple assets capable of driving a step-change in AI compute. EVA runs several programmes in parallel to ensure the best technologies are backed and can thrive. Our unique innovation model supports a fail-fast/fail-forward approach through structured programmes combining hands-on engineering effort with commercialisation support. One such technology is the work undertaken in project ATLAS. This project rethinks how graph data are processed in hardware, by introducing a memory fabric that is naturally tailored to store graph-format data and accelerate bespoke graph processing operations.

evatechnologies.ai | **atlas-processing.com**

Array Control (ArC) instruments

ArC Instruments is a CEF startup that was developed while at the University of Southampton to deliver high performance testing platforms for characterising 'en masse' novel semiconductor technologies in a fast and automated fashion. Its products are contributing to technological advances at global electronics companies and >300 research institutes around the world. ArC Instruments continues to maintain a close, working relationship with the Centre for Electronics Frontiers now at the University of Edinburgh, through supporting and complementing research at the University and providing opportunities including internships and PhD placements.

arc-instruments.co.uk

02 Policy

Our staff are experienced in communicating ideas and practices across a wide range of audiences, including government (e.g. participating at round-tables with ministers, DSIT), policy making bodies/societies (RAEng, Royal Society), funding agencies and the public. We have a track-record in creating evidence-based reports and briefings for funders, researchers, investors, public, government, as well as contributing to shaping national strategies and policy papers.

AI Taxonomy

In order to provide a common language for discussing the key facets of AI, Academy Chair in Emerging Technologies, Themis Prodromakis and Alex Serb worked with the Royal Academy of Engineering to develop an AI taxonomy. This can enable researchers, developers, and policymakers to understand where they are intervening within the wider AI system and encourages consideration of the implications of design decisions at other layers. This report has also been featured in a video available on RAEng's website.

raeng.org.uk/engineering-responsible-ai

Shaping National strategy

The Centre for Electronics Frontier's impact is further evidenced through its input into the creation and delivery of technology roadmaps and engineering practices, including the ASTRID DSTL-funded initiative that led to the establishment of the 'Novel Compute' programme, the UK National Semiconductor Strategy and a range of rapid technology assessments (RTAs), policy papers and reports on 'Neuromorphic Computing' and Future AI compute capabilities.

Contributing to International roadmaps and standards

We are recognised as an international centre of excellence across semiconductor technologies and AI. Our members participated in the international Semiconductor Research Corporation (SRC) Emerging Research Devices Working Group, shaping the International Technology Roadmap on Semiconductors (ITRS). We have also contributed as international experts in DARPA's Electronics Resurgence Initiative (ERI) that led to the US CHIPS and Science Act 2022. At a European level, Themis Prodromakis has served as one of three UK ambassadors for the European Innovation Council (EIC) and is a member of the British Standards Institute (BSI) "ART/1 - Artificial Intelligence" Committee, which brings together a wide range of stakeholders to feed their views into establishing international standards for AI. Themis has also served as a member of the IEEE Nanotechnology Council, a multi-disciplinary group created to advance and coordinate research and education in the field of nanotechnology.

03 Outreach

We believe it's important to give back to the community and we enjoy creating targeted activities to engage children both at our premises and by visiting schools. By working closely with teaching staff, we are able to focus that support specifically where it is needed through our dedicated outreach programmes. We deliver our activities externally in both schools and colleges.

During the 2020 summer lockdown period we filmed several lessons for upper primary school children which we uploaded on our YouTube channel and promoted them to local schools. This activity was subsequently noted by the Royal Academy of Engineering and shared with over 2000 schools nationally.

Deepika Yadav delivers STEM activites as part of the School of Engineering's Milne lectures outreach activity programme.


In the classroom

Introducing the nanoworld

nature nanotechnology

CEF's unique outreach activities that introduce the nano-world to primary school students were featured in Nature Nanotechnology volume 12, page 832 (2017).

Santhosh Sivasubramani, visited Portobello High School to take part in a STEM speed networking activity hosted by Developing the Young Workforce Scotland. Santhosh used an Avengers End Game analogy to encourage engagement.

APRIL and the Tower of Techport

Another initiative for primary school children that we have very much enjoyed working on is the 'APRIL and the Tower of Techport' book, delivered by our APRIL AI Hub team. An exciting, inclusive, and accessible resource for young audiences, over 3000 copies of this book have been distributed to over 400 schools across the UK. This project was funded by the Royal Academy of Engineering.

Caterina Sbandati and Themis Prodromakis deliver a fun interactive activity "transform into neurons", exploiting in practice how biological signals are communicated and detected. This activity was part of the Lindemann Trust outreach event at the University of Edinburgh.

Milne Lecture Series

Themis Prodromakis delivering his inaugural lecture, and the Milne lecture, as Regius Professor of Engineering at the University of Edinburgh.

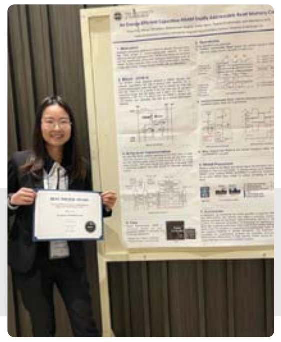
04 Recognition

We are always happy to share in each other's successes, whether this be through invited talks, best paper awards or our excellence in teaching.

Ben Rowlinson top paper award pics at Nature Conference Materials for AI, AI for Materials in Daejeon, Korea February 2025.

Our members are part of a thriving community of researchers in the School of Engineering and we celebrated the success of several of our members at the recent School Postgraduate Conference:

Yihan Pan receiving best paper award, MEMRISYS Seoul, Korea, November 2024.



Caterina Sbandati receiving Best Demo Award at School's Postgraduate Conference.

Deepika Yadav of CEF is the current Engineering Graduate Society President and encourages our active participation in all their activities.

Our staff excel both in research and teaching and play a pivotal role in nurturing talent. It's great to see our efforts being recognised by our own students, as for example with Shiwei Wang's nomination in the Students' Association as "Teacher of the Year 2023" and "Supervisor of the Year 2024".

Top 100 in Neuroscience

Our paper where we used memristors to connect brain and silicon neurons (Sc. Reports, 10, 2590, 2020) has been very popular with the community (>43k downloads), featuring in the top 1% of all Neuroscience papers published in this journal.

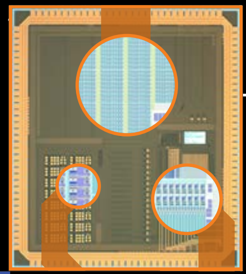
Blavatnik Awards Young Scientists

The Centre for Electronics Frontiers has brought the memristor technology a step closer to becoming viable in the electronics industry. Themis Prodromakis was a recipient of the Blavatnik Award in 2021 in recognition of his research and entrepreneurship contributions.

DISCOVER OUR

CHIP GALLERY

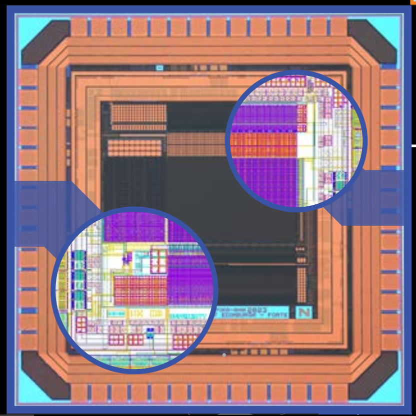
Should you visit us in Edinburgh you will have the chance to appreciate our people and our labs, but also our creative side through an extensive display of “art-on-chips”. A few of these are illustrated below.



PreSONIC

Designers: Grahame, Xiongfei, Shiwei

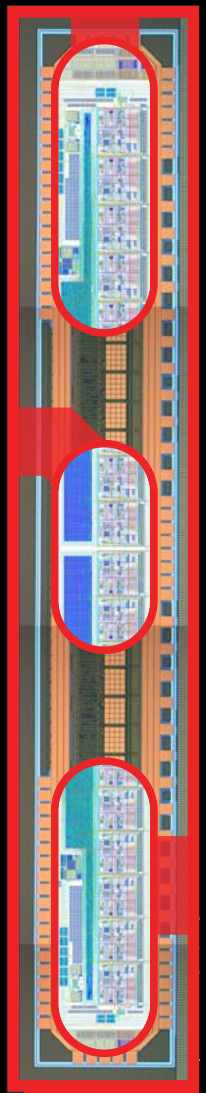
Purpose: A Scalable, Multi-Function, Integrated CMOS/Memristor Sensor Interface for Neural Sensing Applications



SPIKA

Designers: Khaled, Yihan, Grahame, Alex

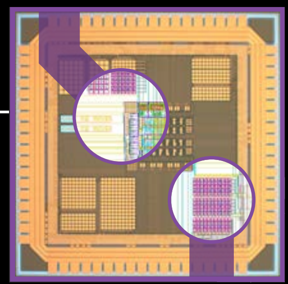
Purpose: An Energy-Efficient Time-Domain Hybrid CMOS-RRAM Compute-in-Memory Macro



NeuroStripe 1.0

Designers: Xiongfei, Shiwei

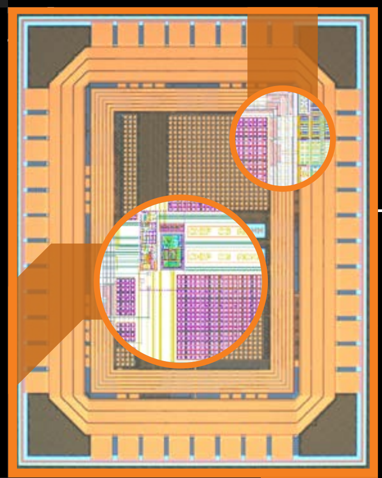
Purpose: Bidirectional multi-channel neural interface chip for closed-loop neuromodulation, version 1.0



ACNN2

Designers: Sachin, Himadri, Mike, Alex

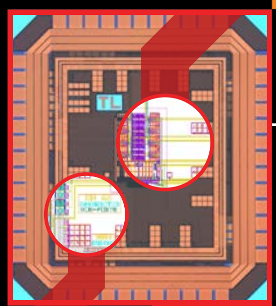
Purpose: Adiabatic neural network for ultra-low-power AI inference, option 1



ACNN3

Designers:
Sachin, Himadri, Mike, Alex

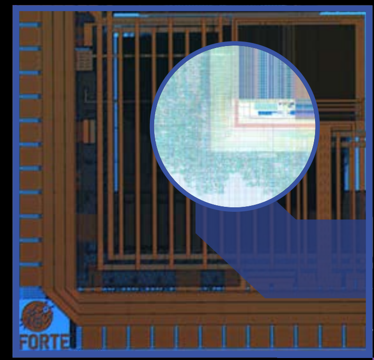
Purpose:
Adiabatic neural network for ultra-low-power AI inference, option 3



Aggregator

Designers: Khaled, Yihan, Alex

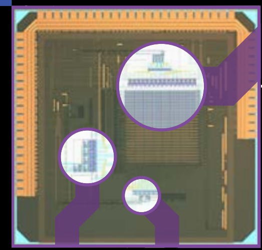
Purpose: Analog-Domain aggregator circuit for RRAM-based neural network Accelerators



ASOCA1

Designers: Yihan, Shady, Alex

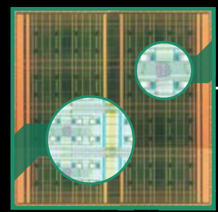
Purpose: RRAM Content addressable memory for symbolic AI processing, 1st generation



TXL

Designers: Georgios, Shady, Ahmet, Themis

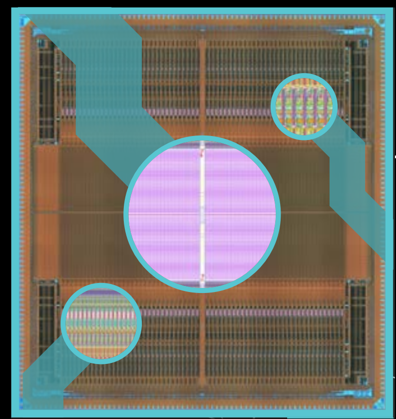
Purpose: Analogue content addressable memory macro for template matching at the edge



ASOCA2

Designers: Yihan, Yanjun, Alex

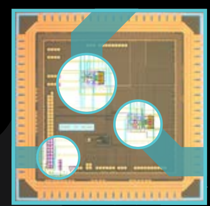
Purpose: A modular graph database accelerator



MELITA

Designers: FORTE design team (14 contributors)

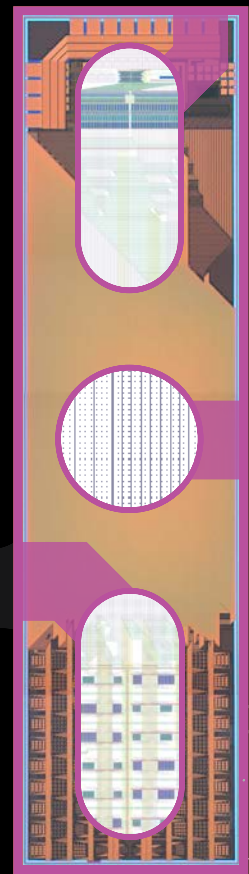
Purpose: Integrated characterisation platform for emerging RRAM technologies supporting up to 1 million DUTs



ACNN1

Designers: Sachin, Himadri, Mike, Alex

Purpose: Adiabatic neural network for ultra-low-power AI inference, option 1



RADTEST

Designers: Ahmet, Alex, Themis

Purpose: Test structure for radiation hardened RRAM memory cells

BE INSPIRED BY A SELECTION OF

CAREER FEATURES

Our research staff past and present are our main asset. Everyone's story and how they arrived in CEF and contribute to it is of interest. Here we showcase a few such stories.

Isha Gupta

Director of Product Management and Field Clinical Engineering
Driving the future of healthcare by developing transformative bioelectronic medicines that push boundaries. Passionate about innovation, problem-solving, and creating solutions that enhance patient care and global health.

Finished school **2007**

Finished Engineering **2011**

PhD **2014-2018**

MBA Imperial College **2024**

Director, Product Management and Engineering **2017-Now**

What did you enjoy studying at School?

I enjoyed studying science subjects, including chemistry, mathematics, and biology. When it came time to choose between pursuing a career in medicine or engineering, I chose engineering. I was uncomfortable with the sight of blood and couldn't envisage an ideal future in medicine. Ironically, today I work in the deep-tech medical device industry, specialising in implantable medical devices.

Tell us about your experiences as part of the CEF team

Right from the start of my PhD with CEF, I was exposed to fantastic opportunities. In my first month, my supervisor encouraged me to travel to Australia for a conference. It was truly inspiring to work in an environment that prioritised networking, mentorship, and exposure to leading scientists in the field. My PhD focused on developing a solution for real-time processing of neuronal signals in a power-efficient manner using memristive devices with applications in the field of brain-computer interfaces.

Please describe a typical day for you working in Galvani

As I was completing my PhD, I decided to transition into industry. The previous year, Galvani Bioelectronics, a joint venture between GSK and Verily, had been established. They announced internship opportunities, and I was fortunate to secure one. Since then, I've spent the past seven years with Galvani, contributing to the development of implant-based therapies that modulate neural signals to treat disease. The first product in clinical trials is for patients living with rheumatoid arthritis. I have held multiple roles in Galvani but currently my focus is on supporting first-in-human clinical trials. It's a rewarding experience to work with patients directly and on a solution which can help improve people lives.

How have you further developed your skills to adapt within your role?

In my current role as Director of Product Management, I place a strong emphasis on continuous growth and development. Recognising the value of expanding my skill set, I enrolled in a MBA program at Imperial College Business School two years ago. I am looking forward to working on projects where I can apply my business knowledge. As a part of my MBA, I worked with ViiV Healthcare, one of the biggest pharmaceuticals working in HIV prevention and I am eager to develop my career further in commercial roles in the healthcare space.

What might we find you doing if you weren't an Engineer?

I've always been drawn to the art-related industries, especially interiors, and oil-paintings. It was my first choice before engineering however I could not pursue it at that time. I like to approach life with an 'out-of-the-box' perspective, and I wouldn't be surprised if I venture into this one fine day.

Grahame Reynolds

Grahame started his career in 1984, after graduating from the University of Surrey. He accumulated four decades of experience in semiconductor IC design, having held positions within Philips, Cypress, Semtech, Atmel, vivaMOS and Nordson. His research interests concern Medical Electronics, Image Sensors and the future prospects of both through the application of AI.

Finished Engineering **1980-1984**

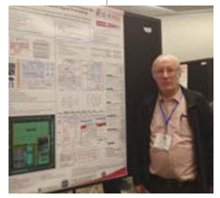
IC Project Leader, IC Library Design Manager, IC Program Manager **1984-1996**

Manager, IC R&D **1996-2011**

Senior Engineer **2011-2016**

IC Architect **2016-2021**

PhD Nanoelectronics **2021-2025**



When did you first know you wanted to be an Engineer?

I grew up in an engineering family, with an inquisitive mind and a love of problem solving, which I still have to this day. My career in electronics actually started when I was 11 years old. I was looking into the dimly illuminated workings of a valve television and asked my father how it worked; he said he had no idea. I was firstly shocked, because I'd never heard him say that before, but secondly I was highly motivated to find out the answer myself. From that moment, electronics became my hobby and my career for the next 50 years!

What was your first job after graduating

While studying electronics at Surrey, I was introduced to the relatively new discipline (at that time) of silicon chip design. I was captivated by the whole subject. After graduating, I joined Philips (formerly Mullard) as a trainee chip designer. Powering up my first chip was a very nervous experience, but seeing it jump into life was exhilarating. A feeling I would go on to experience nearly 100 times during my career.

What made you decide to apply electronics to the medical application?

My life changed after suffering heart problems in 2010. Although very unpleasant, there is no greater motivation to 'change' than being reminded of ones' own mortality. It was during that time I became aware of how many medical conditions lacked any warning or means of early diagnosis. This was a problem that needed to be solved and perhaps electronics was the key. I felt an obvious compulsion to refocus my career on sensors and medical electronics.

How did you come to join CEF?

I was designing X-ray sensors and wanted to test their behaviour after prolonged exposure to radiation.
A group at the University of Southampton (MicroVIS) had a lot of experience and capabilities in such matters and while working with them, I became aware of the activities of the CEF group and I joined the group later that same year.
Being a mature PhD student does have many advantages, most notably four decades of experience, sharp focus, strong motivation and passion for the subject matter. It's been a pleasure to pass on my experience to others. I think it's important that as people approach the end of their careers, they should find a mechanism to do just that, otherwise it is lost and must be relearned time and again.

If you hadn't been an Engineer what might an alternative career have been?

In my spare time I have undertaken some creative pursuits; I am an amateur author, artist, musician. Given that I have always enjoyed writing, I think I may have pursued that in some form, possibly journalism. I am also a former international chess player, but there's not a lot of demand for that!

CAREER FEATURES

Peter Lomax

After a varied career Peter studied engineering as a mature student before pursuing a career in optoelectronics integration and packaging. Peter then returned to semiconductors, initially as a process engineer for commercial activity at the University of Edinburgh then as cleanroom Director, managing the operation of the Scottish Microelectronics Centre cleanrooms used by CEF researchers. Peter also co-supervises a number of PhD students outside of CEF, has been Principal Investigator on industrial research projects and leads the cleanroom commercial activities.

British Antarctic Survey Radio Operator **1987-1990**

Cardiff University BSc Electronics **1994**

Consultant Telecom Engineer **1994**

Cardiff University PhD – GaInP HEMT Devices **1999**

Laser Physicist Optical Integration **2000-2004**

Applications Engineer **2004-2006**

Process Engineer **2006-2018**

Cleanroom Manager **2018-Now**

Were you always attracted by engineering and technology?

My step-father was an engineer in the airforce so I grew up with a background interest in engineering.

How did you apply your technical training?

After completing a Technician Diploma in 1983 studying electronics I enjoyed several short term technician jobs, most notably for GEC before spotting an great opportunity to combine my love of travel and engineering by joining the British Antarctic Survey as a Communications Technician in Antarctica sailing from Grimsby in 1987 and returning in 1990. Working in a tight-knit team of only 10 people at any one time, I was responsible for all the radio communications equipment. It was a fascinating experience, and a great opportunity to practice winter sports such as skiing and ice climbing!

Following two years in Antarctica I travelled back to the UK via South America, and after briefly working for Green Peace on Rainbow Warrior 2, I decided to continue in education initially for degree and then a PhD working for a year in between for a communications consultancy travelling across Europe as a consultant engineer.

What made you do a PhD after all these adventures?

I was keen to delve deeper on the theory side, but also to gain more access to cleanroom facilities to learn more complex fabrication techniques.

Towards the end of my PhD I did indeed get more access to the cleanroom environment and this resulted in a chance to work for a year in Los Angeles for a solid state laser fabrication company before moving to Scotland for an optical start up (Kymata) as a packaging research engineer and then for Shin-Etsu Handotai Europe as a technical support engineer. However, I wanted to return to a role where I could create, and hence in 2006 I became the first fabrication employee of the university cleanroom in what is now the Scottish Microelectronics Centre (SMC), which I eventually took over managing.

How has the arrival of the CEF researchers changed your role?

The cleanroom is a highly regulated commercial activity. We interact with industry in an innovative way by hosting resident companies, allowing access to external companies and having a dedicated commercial team of engineers whilst also being open to all University academic researchers. The arrival of the Centre for Electronics Frontiers research group in 2022 has been entirely positive for the SMC. The capability of the CEF researchers – their talent and interests – has reinvigorated the facility with investments and state of the art equipment, increasing our profile within Scotland and the rest of the UK.

What do you do when not to be found in the Cleanroom?

I'm a keen motorcyclist and I also enjoy writing and sketching.

Chris Giotis

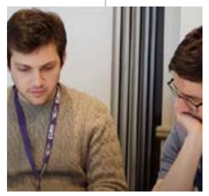
Chris is a Research Associate and co-investigator at a High Growth Spinout Programme, funded by Scottish Enterprise. He obtained his PhD in AI Hardware with CEF. Chris is leading the commercialisation of ATLAS, a hardware accelerator for faster digital payments and real-time fraud detection.

MEng Electrical and Electronic Engineering **2018**

PhD Electrical and Electronic Engineering **2022**

Research Associate in Graph Databases **2022**

ICURe Explore Grant from UKRI **2023**



High Growth Spinout Programme **2024**

Did you always want to study Engineering?

No! In fact, you could say I was a somewhat reluctant engineer. I only found interest in the field when I realised its broader applications and societal benefits. As a teenager I wished to study economics because it felt like an interesting lens to look at the world through, but I was persuaded to study engineering and gain better foundations in analytical thinking. It turned out to be the right call, and all finally made sense to me when I managed to combine my studies with fields like behavioural neuroscience, evolutionary science and game theory. I then knew I wanted to apply engineering to real problems!

What was it about Neuroscience that appealed to you?

It all coincided with the rise of deep learning and AI. It was clear to me that what was needed for autonomous AI was some form of independent memory system. As an undergraduate I studied both how synapses store memories in our brains and facilitate intelligent thoughts, and how we approximate this algorithmically. I then asked myself, why not build it in hardware? Enter CEF...

How did you come to join CEF?

I met Themis during a lecture he gave. He began talking about the synapses I was already studying but from an electronics perspective and I was instantly hooked! We had very common interests in how memory works, particularly in the works of Eric Kandel in biological synapses. CEF then was 6-8 researchers but there was a very powerful energy and ambition to innovate and push boundaries. Themis's vision was (and still is) infectious. This aligned perfectly with how I wanted to work and my desire to have impact. I joined as a PhD student and immediately felt at home in the group. It is great to see CEF now becoming what we always imagined it to be!

Describe your current role

The end of my PhD synchronised with CEF's relocation to the University of Edinburgh, a move with a big entrepreneurial aspect. During the last two years, I have been focusing on the translation of our research into AI hardware products. We have received a High Growth Spinout Programme Grant from Scottish Enterprise to bring ATLAS, our Graph Database accelerator, into the market. My role has shifted from pure research, to market research, business plan development and overall commercialisation strategy. This has been a wonderful challenge and journey since academia and industry are two very different approaches.

Are there any things you think we could learn from industry and how they approach problems?

In academia we sometimes think almost too much before we take action. Industry, particularly start-ups, do more in less time and learn from their mistakes. Move fast, break things. We need to adopt that more.

What next?

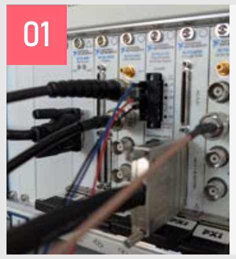
I am very happy with the developments in our ATLAS project, an AI chip that could detect fraudulent payments transactions 10x faster than current Cloud-based solutions. Our first demo will be available soon and we are working tirelessly to build upwards. Overall, you should be expecting very exciting things coming from CEF!

A WALK AROUND THE

CEF TESTING LABS

The CEF labs are at the forefront of emerging nanotechnology research. They offer state-of-the-art semiconductor characterisation facilities and enable a range of emerging nanoelectronics device and systems testing, novel semiconductor films characterisation and bioelectronic interface measurements.

01



Chip test instrumentation

Data acquisition and interfacing equipment for general analogue/digital characterisation and testing of chips and devices.

02

PCB soldering and rework station

The lab is equipped with a host of soldering equipment. Standard soldering irons are complemented by hot-air tools, hot plates, air extraction, a stock of components, and electronic testing equipment.

03

Network analysis

The R&S ZNB40 VNA enhances the labs' ability to develop high-speed RF PCBs and RF components. It has a frequency range up to 43.5 GHz and wide dynamic range of 140 dB.

04

Scanning Electron Microscopy with element analysis

Fast-turnaround imaging at much higher magnification than standard optical microscopy with X-Ray element analysis for composition mapping across surfaces.

05

Keithley 4200 parameter analyzer

The parameter analyzer is a Versatile multi-purpose electronic characterisation capability including I-V, C-V and ultra-fast pulsing.

06

Manual probe stations with RF and optical capabilities

Two 150 mm probestations with coplanar GSG RF probes suitable for high frequency characterisation of chips and waveguides up to 40 GHz. The stations also support advanced optics for optical signal sourcing and acquisition.

07

Semi-automatic probestations

Two state-of-art semiautomatic probestations (Cascade MicroTech Summit 12K and MPI TS200-IFE) support large-scale, high-precision, automated testing with accurate positioning of up to 200 mm wafers and over a temperature range of -60°C to 300°C in electrically and environmentally isolated microchambers.

08

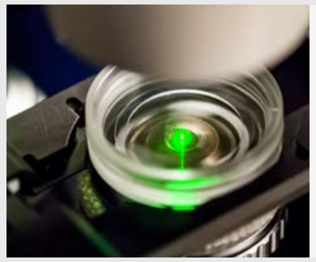
Atomic Force Microscopy

The Park NX20 offers a wide range of measurement capabilities for surface analysis for up to 6" wafers. It can do standard surface roughness and 3D structure measurements while offering additional modes for in-depth analysis. These include Kelvin Probe Microscopy, Conductive AFM Microscopy and Magnetic AFM modes all in an electrically isolated environment with a temperature range between -25C and 180C.

09

X-Ray Diffractometry

X-Ray analysis with the Bruker D8 Discover for bulk and grazing incidence diffractometry, stress analysis and reflectometry. Equipped with a high-intensity X-Ray source and both 1D and 2D detectors.



10

Confocal Imaging

The Zeiss LSM confocal microscope is designed for imaging fluorescence of transparent or translucent samples on biological and chemically functionalised samples. It can produce image stacks for 3D visualisation and supports muti-wavelength excitation (487-594 nm).

11

Solution-based thin film manufacturing and characterisation

Equipment for deposition of solution-processed materials via spin coating, as well as for depositing metals in high vacuum. The tool is also equipped with a probe station, allowing for the full manufacturing and characterisation of optoelectronics in a controlled environment.

12

Wet processing area

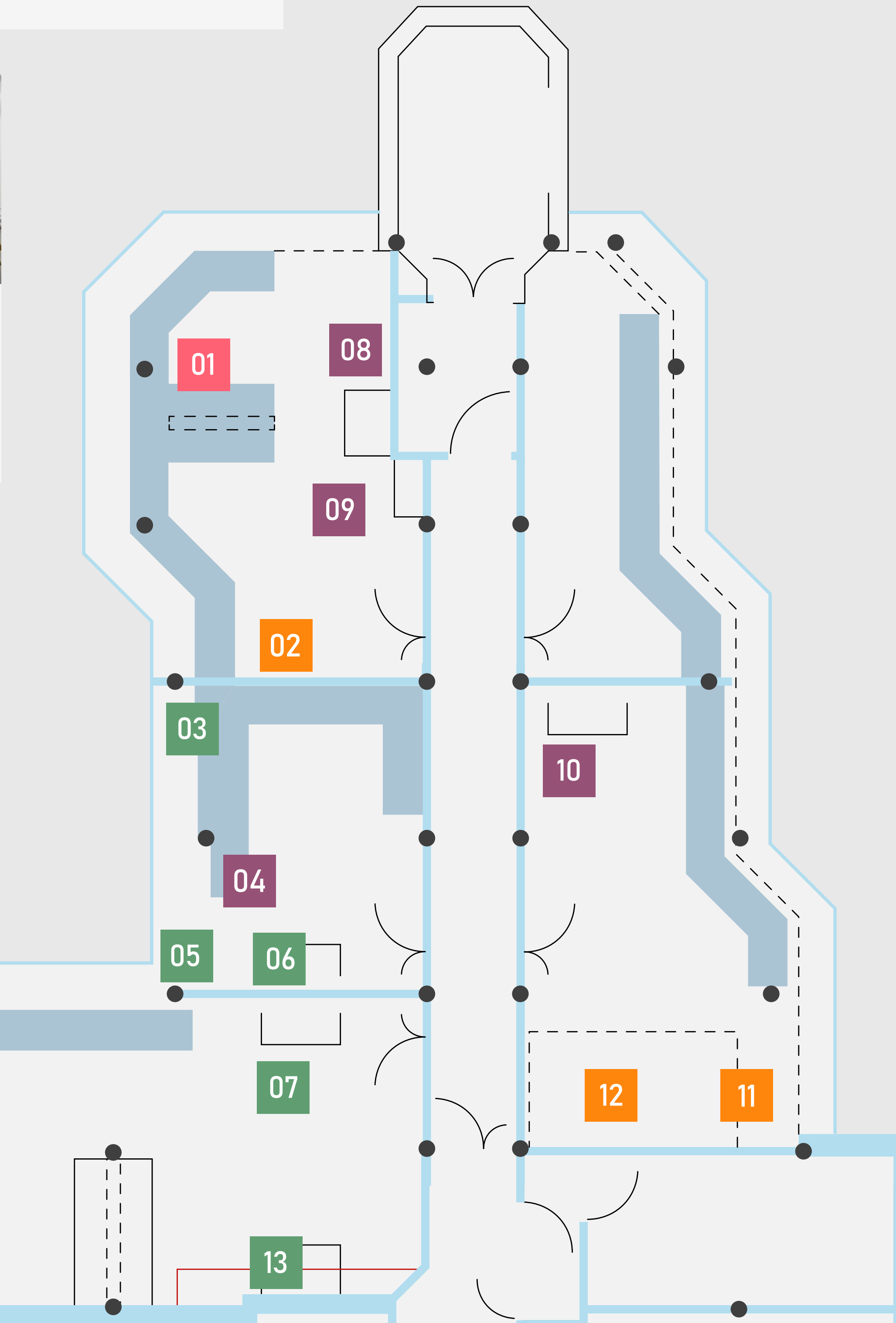
A general wet chemistry environment for surface cleaning and modification of substrates. Services include nitrogen, CDA, ultrasonic cleaning, spin coating and hot plates.

13

Manual probe stations

Modular, multi-purpose probe stations can be configured for unusual samples and process depending on the demands of the user while providing all the standard I-V/C-V characterisation tooling and either coax or guarded triax connections.

- Data acquisition and digital testing
- High precision electronics characterisation
- Semiconductors and device analysis
- Manufacturing and processing



A VIRTUAL TOUR OF THE

SCOTTISH MICROELECTRONICS CENTRE

CEF is fortunate to be part of the Scottish Microelectronics Centre (SMC) that offers commercial and academic clients access to state-of-the art facilities and in-house expertise in areas such as micro-electro-mechanical systems (MEMS), semiconductor, and nanofabrication. All tools are capable of processing wafers from 3″ to 8″.

F&S Series 53 Wirebonder

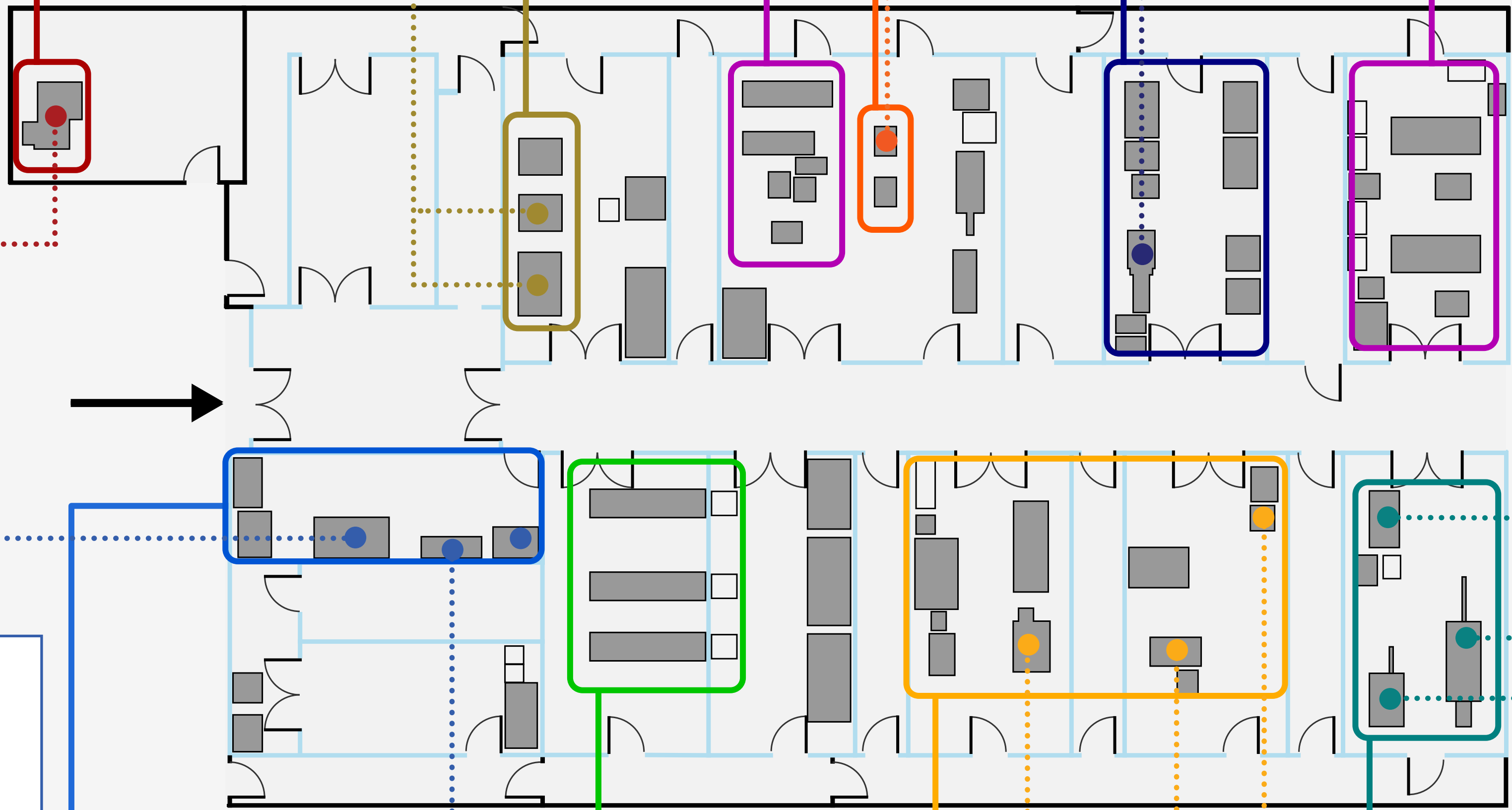
Flexible manual wire-bonder supporting both ball and wedge toolheads for bonding and packaging applications.

Plasma-Therm ICP

Chemically reactive plasma etching tooling with adjustable parameters for maximum efficiency in deep etching applications.

DISCO Saw and Grinder

Sawing, grinding and policing facility for BEOL and packaging processes.



Thermofisher Nexsa G2

Highly integrated surface analysis facility with X-Ray Photoelectron Spectroscopy, Angle Resolved XPS, Ultraviolet Spectroscopy, Ion Scattering Spectroscopy, Reflected Electron Energy Loss Spectroscopy and Raman.

Veeco Fiji ALD

Plasma assisted Atomic Layer Deposition tool for conformal atomically-thin coatings of dielectrics and metal-oxides. The tool supports depositions up to 300C with in-situ ellipsometry.

Angstrom Sputterer

Multi-purpose flexible deposition system for reactive sputtering process including oxides, nitrides and oxynitrides. It features 3 RF and 3 DC magnetron sources including strong permanent magnets for magnetic materials and alloys.

Angstrom Evaporator

E-beam and thermal evaporation tool for deposition of metallic and non-refractory materials. It has a single thermal and six electron beam sources.

Leica DM12000

Optical inspection and metrology microscope with 8″ wafer support, multi-image stitching and mixed Optical/UV observation modes.

TESCAN SEM

High resolution scanning electron microscope with Energy-Dispersive X-Ray Spectroscopy capacity for imaging and analysis of fabricated devices and materials.

Brüker Dektak Profiler

Profilometer for quick metrology of deposition processes.

Karl-Süss MA8/BA8

Manual mask aligner supporting 200 mm wafers with backside alignment.

Nanofrazor

Thermal direct-write nanolithography tool for patterning feature sizes down to 150 nm.

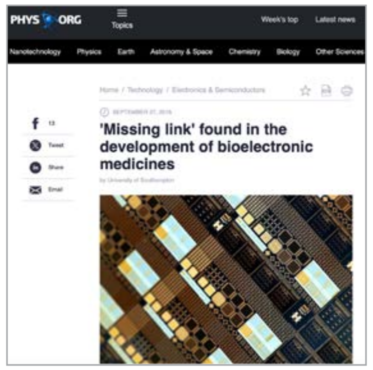
DMO Lithography

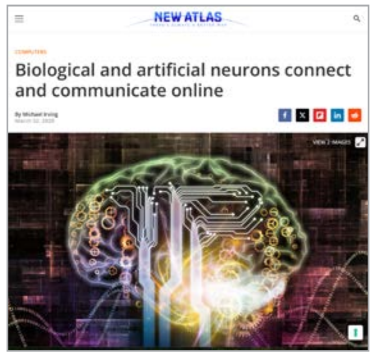
Maskless lithography tool with resolution of 1 μm for rapid prototyping of new patterns and designs.

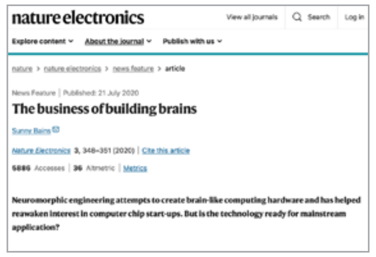
DISCOVER

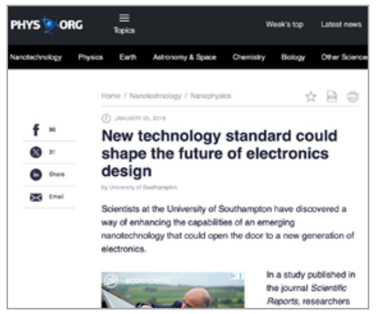
CEF IN THE NEWS

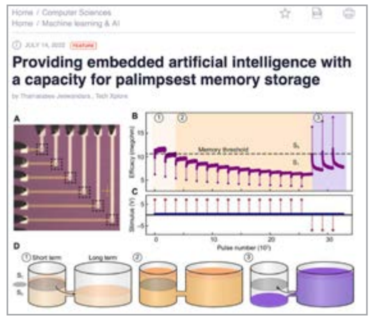
As an outward looking Centre we enjoy communicating and featuring in good news stories relating to our activities and achievements. We are proud of the fact that our research attracts national and international media interest, enabling broader dissemination of our work and its impact.

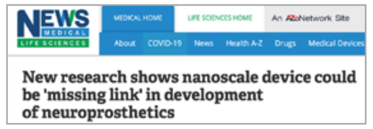


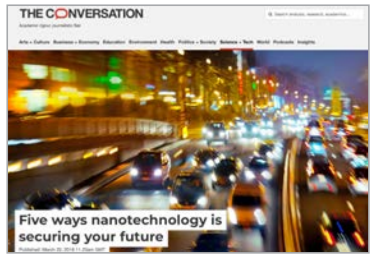












Centre for Electronics Frontiers

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School of Engineering

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