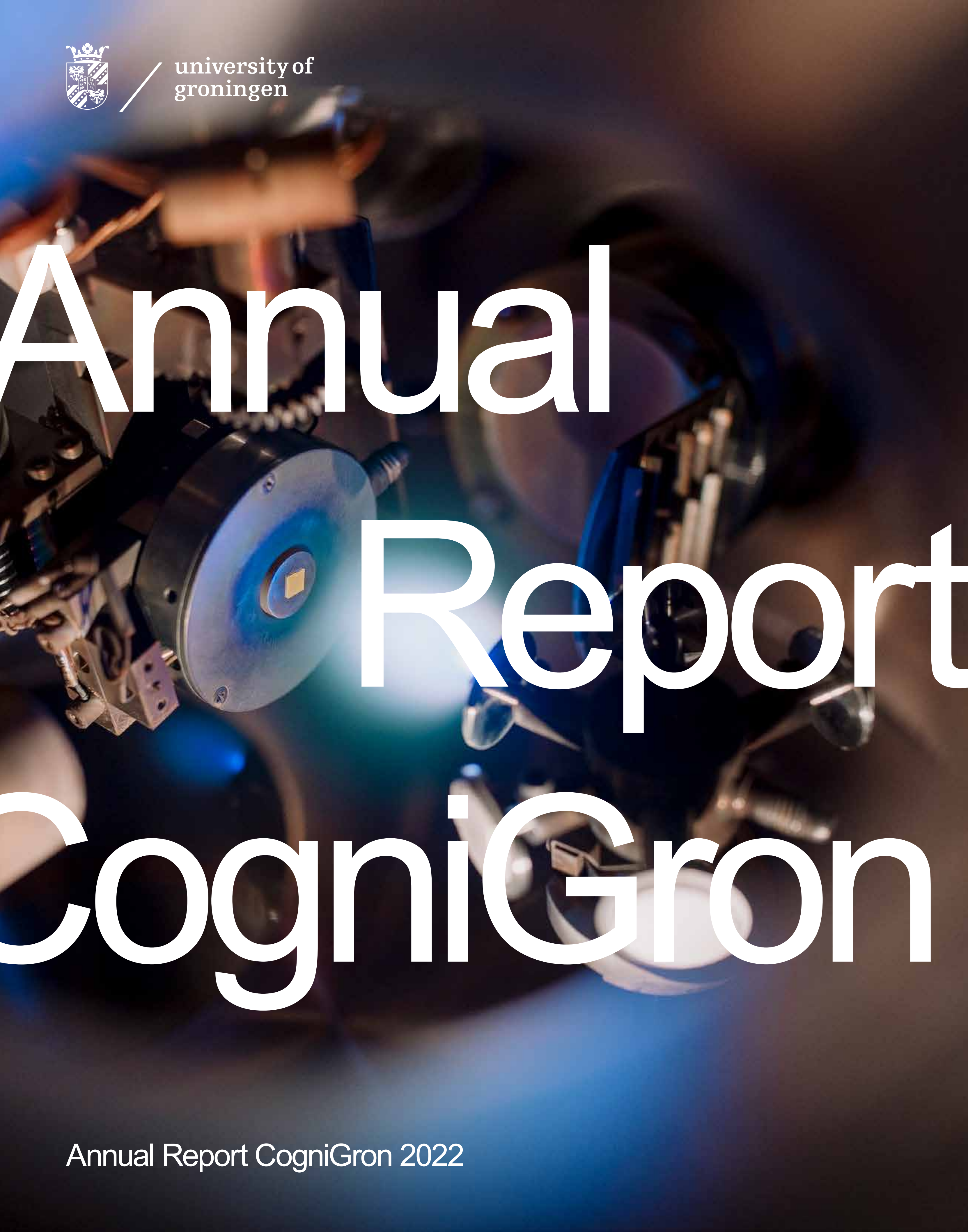
university of groningen



Annual Report CogniGron

Annual Report CogniGron 2022

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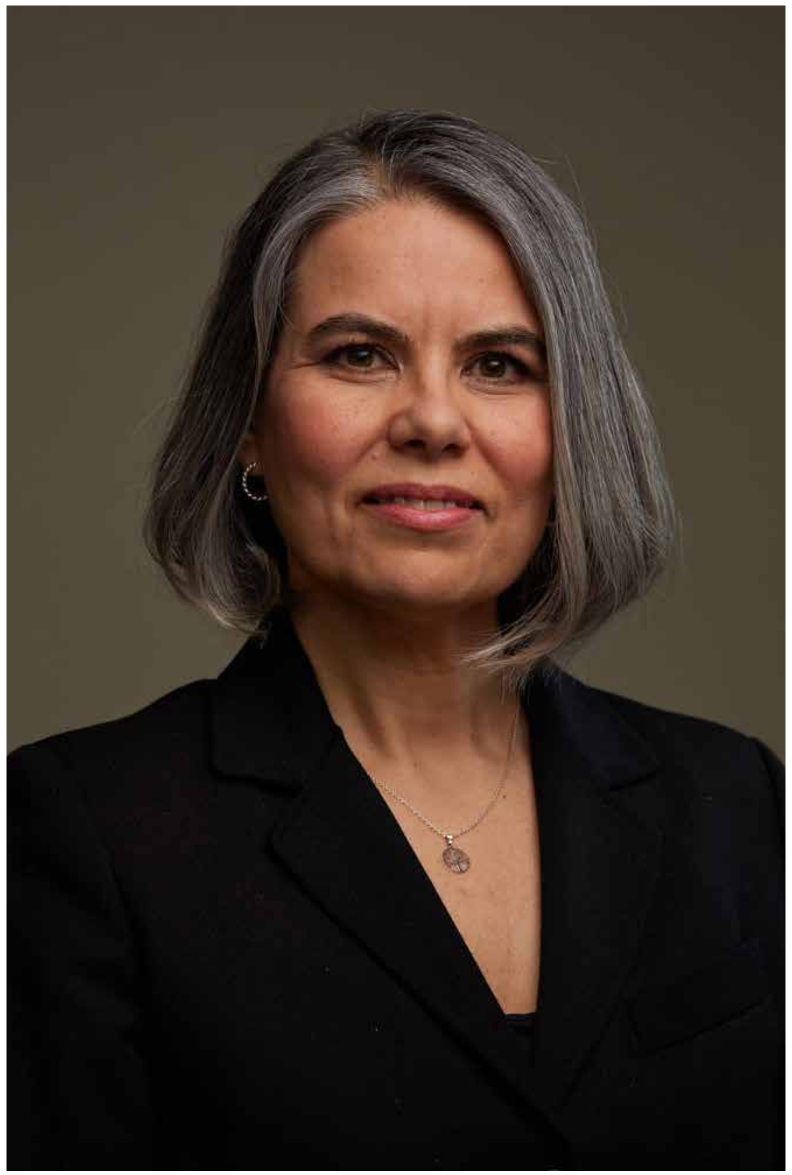


Beatriz Noheda
CogniGron Director

This document is the fourth CogniGron annual report that we have prepared since our foundation in 2018. Until now, in the forewords, the director has offered a reflection on the achievements and progress of the past year. This time, we would like to give the credit to the person who has put these documents together every year and carried most of the weight of the CogniGron office: Dr. Jasper van der Velde.

After five years working for CogniGron and managing the most diverse issues, from arranging double doctorates to writing profile reports for hiring new staff, and many others; now that we are smoothly running, he sees it is time to move onto new challenges. Therefore, this annual report includes a preface, in which Jasper himself analyses CogniGron in 2022.

Thank you for all you have done for CogniGron, Jasper. We wish you the best!

Beatriz Noheda
Director CogniGron

Preface

Jasper van der Velde

Unleashing the Power of Brain-Inspired Computing

As a unique and pioneering research centre, CogniGron aims to educate a new generation of researches and develop a blueprint for future proof computing. Our focus is on innovative, advanced computing and information technologies that are extremely efficient, in particular in terms of energy usage.

We find ourselves in an era of rapid technological advancements. It is our strong belief that with CogniGron we are at the forefront of a transformative journey of how we compute, one that draws inspiration from the most complex and efficient computing system in existence—the brain. As we delve into the realms of brain-inspired computing, we witness the convergence of interdisciplinary research, where mathematics, computer science, material science, engineering and artificial intelligence, are working intensively together. This convergence holds immense promise and potential, offering unprecedented opportunities.

New talents

In the five years since CogniGron was founded, we have built an interdisciplinary community where, the whole team (scientists and non-scientists) are working together, but also relying on their own expertise and strength. During the year 2022, we continued to attract talented researchers to Groningen, further expanding our team and advancing our mission. This included new professors as well as PhD students, the backbone of CogniGron.

Because we believe that only by working together, we can move forward, with researchers from Groningen and abroad, we started working together with various other universities and companies in 2022. We participate in numerous consortia in Europe. A special mention to Western Sydney University and University College London with which we started a formal working agreement to advance the field of neuromorphic computing. It is truly exciting to work in this field as more and more initiatives have a global scope. CogniGron is, because of the financial donation (CogniGron received a large donation of an alumnus who wishes to remain anonymous), in a unique position and can take a leading role herein.

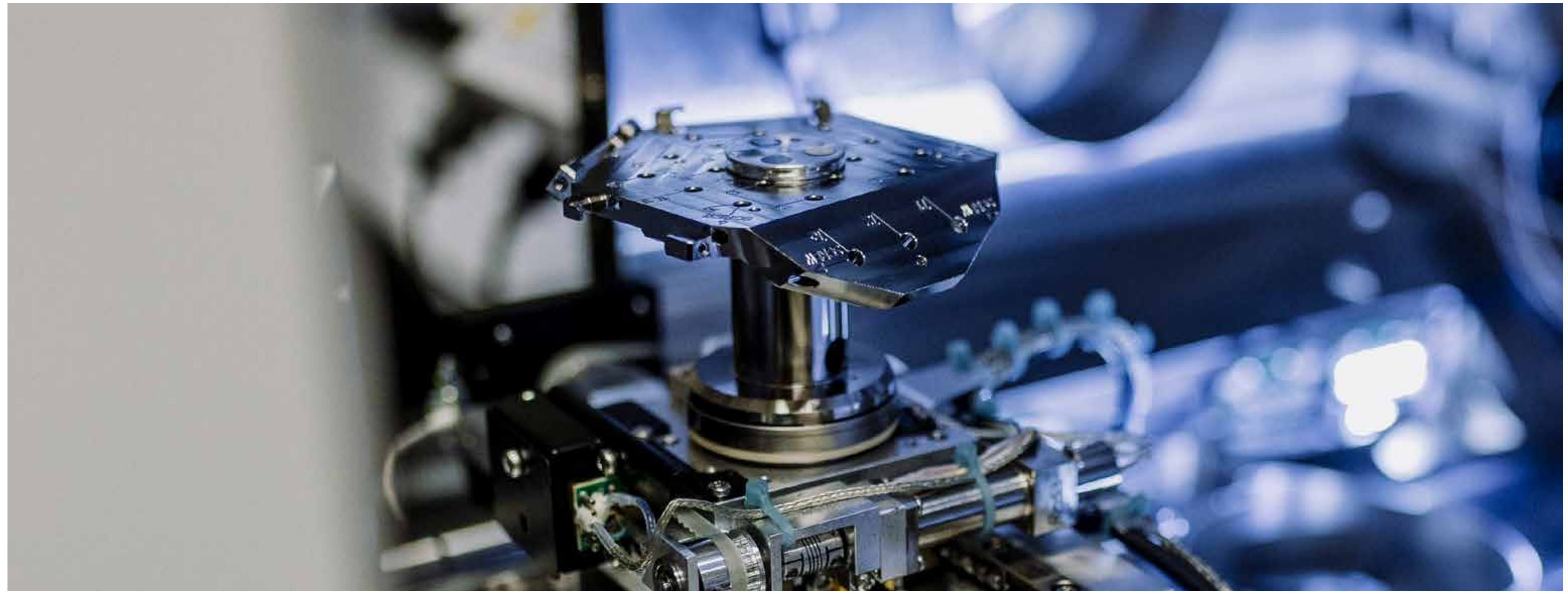
Driving force

With this in mind, I am optimistic about the future of computing. We are convinced we are a driving force for change, together with our excellent researchers, partner universities, companies and other (research) organisations.

In this annual report, we also showcase our latest advancements, highlight groundbreaking research, and provide insights into the emerging trends that are shaping our future. We celebrate the collaborative spirit that underpins our transformative journey, recognizing that the pursuit of knowledge and innovation within CogniGron is a collective one. Together, we are working on a future proof way of computing.

Jasper van der Velde
Scientific Coordinator CogniGron

Rethinking Computing



What if computers could process unprecedented amounts of complex data? What if people all over the world could benefit from this new computing force, in a way that doesn't exhaust our planet's energy resources? What if we could rethink the way computers work? Well, we can. We are CogniGron and we are on a quest for the future of computing.

Groningen Cognitive Systems and Materials Center (CogniGron), based at the University of Groningen, is a unique multidisciplinary research center. We do fundamental research into self-learning materials and systems for cognitive computing – computing that has the ability to learn and to handle complex challenges in a super-efficient way, inspired by how the human brain works. This means rethinking the computer as we know it. So we are on a mission: to find a new blueprint for future-proof computing.

Next generation

We are multidisciplinary by choice and by conviction. Our team of leading experts and next generation talent, unites expertise from physics, materials science, mathematics, computer science and artificial intelligence. In this uncharted territory, we need to work closely together. We are convinced that once we have bridged the gap between materials and theoretical foundations, we're not just shaping the future of computing, we're also shaping the future of computer science as a whole.

The ease of an everyday online search. The immense value of digital communication in today's world. The ability to store and access vast amounts of data. Modern day computing fuels prosperity all over the world. But the current generation of computers is reaching its limits. We need a paradigm shift. A new approach, partly evolution, by benefitting from all the achievements of modern-day computing, partly revolution, by rethinking the future of computing. Because tomorrow, we need a more sustainable way to put huge amounts of data to good use. A new way to overcome our current surging energy consumption challenges. A way that makes the world benefit from computing power. In a way that is acceptable for everyone without overcharging our planet's energy sources.

Materials and systems

Can we develop new materials and systems that are so much more efficient? We believe we can. The proof is literally in our own heads: the human brain. Our brain uses an ingenious neural network to process complex information, far more quickly and efficiently than any computer chip, which sends every bit of information from transistor to transistor, one step at a time. And, unlike current computers, the brain is effectively combining processing and storage, all at once. At CogniGron our research is inspired and guided by the way our mind works.

We cannot predict when we'll achieve a breakthrough in cognitive computing. We are convinced that, eventually, we will. Because we're driven by the need to change the paradigm. Because we strongly belief in a multidisciplinary approach. Because tomorrow's leading computing scientists are a part of our team today. And because we're inviting partners – from science, industry, society and government – to join our mission: to develop a blueprint for future-proof computing.

About CogniGron

CogniGron was founded in 2018 to create the fundamental building blocks for a new type of computing, that is cognitive computing or computing inspired by the brain. These building blocks consist of self-learning materials and devices that can perform the tasks that are currently assigned to thousands of transistors and complex algorithms in a much more efficient and straightforward manner. Hence, these building blocks form the basis for a new generation of computer platforms for cognitive applications, such as pattern recognition and analysis of complex data.

Our Mission

Our mission is to develop a new blueprint for future-proof computing. We aspire to create the conditions for our multidisciplinary and diverse team to work closely together to develop cognitive computing. This goal needs a coordinating effort to come up with solutions at all levels: from materials that can learn to devices, circuits and algorithms.

CogniGron is the first academic initiative of its kind.

Our Goals

CogniGron has set two primary objectives for the upcoming years. Firstly, our focus is on creating the neuromorphic chips that advance state-of-the-art worldwide. We have the potential to do so in two complementary domains: highly specialized full-custom systems solving specific tasks with minimal resources (e.g. power, data, size) and general purpose systems for always-on unsupervised learning. Secondly, we are dedicated to educating the next generation of researchers, with the aim of preparing the pioneering developers of a global-scale neuromorphic chip at CogniGron.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MB 200G

Our Team

In-house Expertise

The strength and uniqueness of CogniGron lie in the physical systems that are investigated (with scalability potential beyond current solutions) and in the multidisciplinary character of the approach. We are multidisciplinary by choice and by conviction. Our team, of leading experts and next generation talent, unites expertise from physics, materials science, mathematics, computer science and artificial intelligence.

Materials Science Expertise

The ambition of CogniGron is to develop and build the fundamental building blocks for cognitive computing, also called 'Cognitive Materials'. The researchers working on these topics are therefore central participants, with leading roles in current research. Materials scientists explore, study and further design electronic materials and devices. The CogniGron research programme encompasses the entire chain of materials research from modelling, synthesis, experiments and theory to device fabrication:

Prof. Tamalika Banerjee
Spintronics of Functional Materials

Prof. Elisabetta Chicca
Bio-Inspired Circuits and Systems

Prof. Maria Loi
Photophysics and Opto-Electronics

Prof. Bart Kooi
Nanostructured Materials and Interfaces

Prof. Beatriz Noheda
Nanostructures of Functional Oxides

Prof. George Palasantzas
Physics - Surface interactions and Nanostructures

Prof. Petra Rudolf
Experimental Solid-State Physics

Prof. Caspar van der Wal
Quantum Devices

Prof. Jianting Ye
Device Physics of Complex Materials

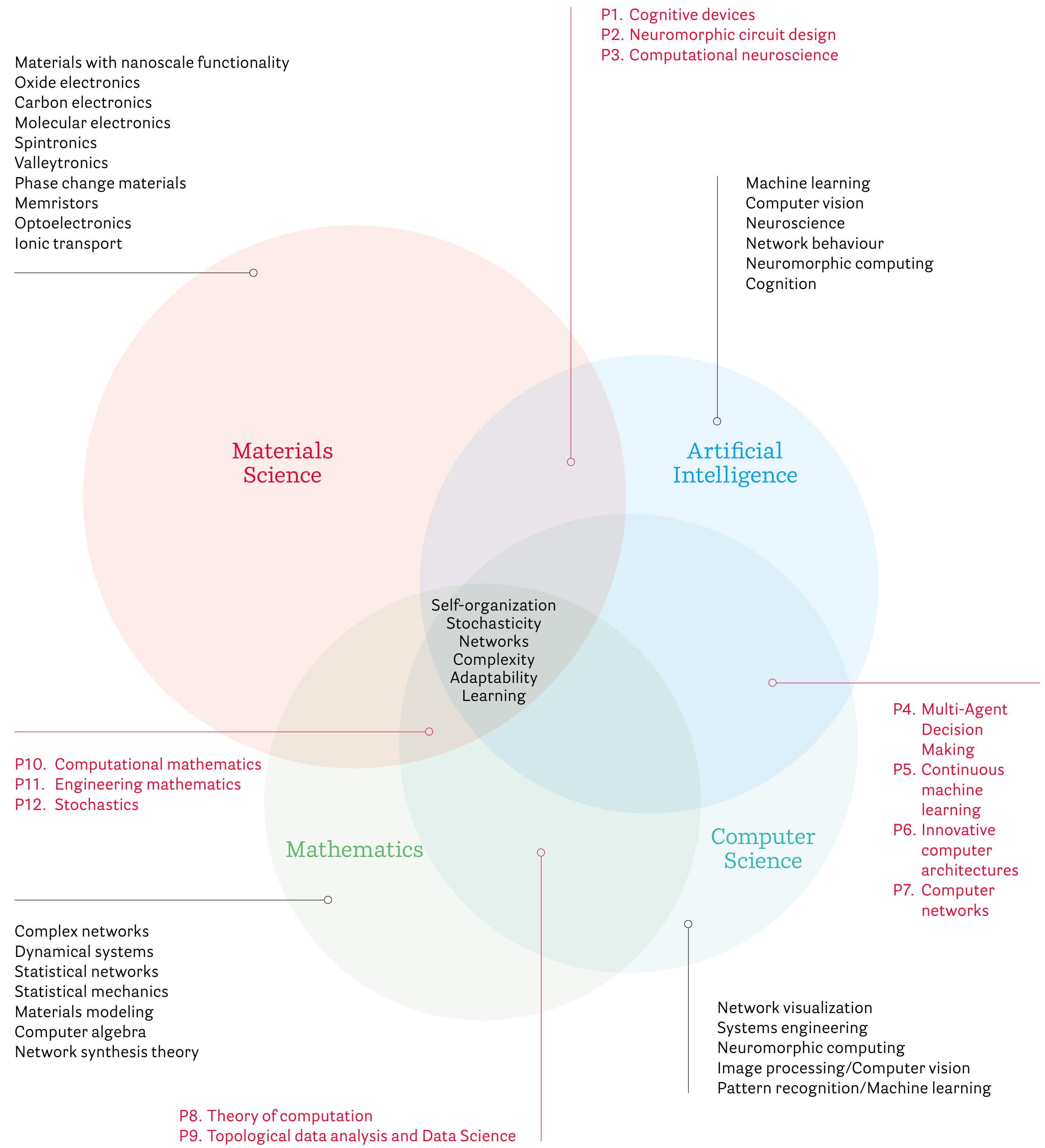


Figure 1 presents the existing expertise related to CogniGron and the relevant disciplines, highlighting the excellent position of CogniGron to make progress in the field of cognitive computing. Over the last three years, CogniGron has attracted new expertise on the borders of various disciplines, aiming to increase synergy and collaboration and providing a bridge between existing expertise in materials science, AI, mathematics and computer science.

Artificial Intelligence Expertise

The availability of large data sets and computing power have led to a revolution in machine learning, notably in the area of deep learning with neural networks. This provides both opportunities and challenges. It should be noted that current neural-networking methods are implemented on "classical computer" called Turing/Von Neumann machines, which is not sustainable for reasons such as a very high energy demand, both for computing and communication functions. In close cooperation with materials scientists, artificial intelligence experts develop models and methods facilitating the search for novel materials that form the basis for a new type of computer, that is a neuromorphic or cognitive computer, that are suitable for neural computing. In this way, CogniGron covers the full range theoretical models of how this new computer should look to finding the actual new materials that form the basis of this new future-proof computer.

Prof. Sander Bohté
Neural Computation

Dr. Jelmer Borst
Artificial Intelligence

Prof. Davide Grossi
Cognitive Multiagent Systems

Prof. Herbert Jaeger
Computation in Cognitive Materials

Prof. Lambert Schomaker
Artificial Intelligence

Prof. Niels Taatgen
Artificial Intelligence

Dr. Marieke van Vugt
Cognitive Modelling

Computer Science Expertise

Computer science is an essential component in the development of cognitive systems and materials. It addresses fundamental issues to understand basic principles of developing and building novel computer architectures. The computer science expertise within CogniGron is broad:

Dr. George Azzopardi
Information Systems

Prof. Michael Biehl
Intelligent Systems

Prof. Georgi Gaydadjiev
Innovative Computer Architecture

Prof. Boris Koldehofe
Computer Networks

Dr. Revantha Ramanayake
Theory of Computation

Prof. Jos Roerdink
Scientific Visualization and Computer Graphics

Dr. Michael Wilkinson
Digital image analysis and computer vision

Mathematics Expertise

A unique feature of CogniGron is the involvement of mathematics. To understand the underlying principles of 'cognitive materials', mathematical principles and modelling are key. In particular, the concepts of networks, control theory and graph theory concepts and tools, as well as the description of dynamics of complex and strongly non-linear phenomena, are of great relevance to design connectivity, adaptivity and plasticity in materials and devices. The mathematics expertise within CogniGron covers a broad spectrum:

Dr. Bart Besselink
Systems and Control Theory

Dr. Gilles Bonnet
Stochastic Studies and Statistics

Prof. Kanat Camlibel
Systems and Control Theory

Dr. Serte Donderwinkel
Topological Data Analysis and Data Science (Start in 2024)

Dr. Julian Koellermeier
Computational Mathematics

Prof. Arjan van der Schaft
Applied Analysis

Dr. Alef Sterk
Dynamical Systems Theory

Prof. Holger Waalkens
Dynamical Systems Theory

Dr. Alden Waters
Systems Control and Applied Analysis

Prof. Fred Wubs
Numerical Mathematics

Technical Support

CogniGron would not be where it is today without the skills that the technicians bring. The technicians amongst others train the students in the various labs and make sure that all labs are running smoothly.

Dr. Masoud Ahmadi
CogniGron (support Microscopy)

Ir. Jacob Baas
Solid State Materials for Electronics

Henk Bonder
Nanostructures of Functional Oxides

Gert ten Brink
Nanostructured Materials and Interfaces

Johan Holstein
Fysica van Nano Devices

Dr. Arjun Joshua
CogniGron (support clean room)

Philipp Klein
Bio-inspired systems and circuits

The Next Generation

CogniGron-funded

Staff members are encouraged to submit joint PhD proposals with PIs from different disciplines. These proposals lead to CogniGron-funded PhD and supporting post-doc positions. Brainstorming and discussion sessions are organized to develop the research plans for these positions.

Anouk Goossens (2018-2021)
Nanoscale memristors for new computing paradigms
Spintronics of Functional Materials group

Dr. Shuyan Shao (2018-2019)
Organic memristors
Photophysics and Opto-Electronics group

Anne-Men Huijzer (2019-2023)
Memristor Networks
Systems and Control Theory Research group

Jan Rieck (2019-2019 and 2023-2024)
Memristor networks from self-assembled domain walls in oxides
Nanostructures of Functional Oxides group

Azminul Jaman (2020-2024)
Towards a cognitive computer architecture based on memristive devices: developing short- and long-term memory
Spintronics of Functional Materials group

Julien van der Ree (2020-2024)
Nanoparticle based percolating networks towards neuromorphic computing
Physics - Surface interactions and Nanostructures group

Saad Saleh (2020-2024)
New switching architectures with memristors for neuromorphic computing
Computer Networks group

Thomas Tiotto (2020-2024)
Towards a cognitive computer architecture based on memristive devices: developing short- and long-term memory
Artificial Intelligence group

Karolina Tran (2020-2024)
Carbon nanotube-based neuromorphic electronics
Photophysics and Optoelectronics group

Daniel Willhalm (2020-2024)
Large deviations in stochastic geometry
Topological Data Analysis and Data Science group

Dr. Oleksandr Zheliuk (2020-2021)
Enhanced learning efficiency of synaptic devices for neuromorphic computations
Device Physics of Complex Materials group

Jhon Kevin Astoquillca Aquilar (2021-2025)
Nanoparticle based percolating networks towards neuromorphic computing
Stochastics and Statistics group

Radu Cimpean (2022-2026)
Smart Electronic Olfactory System
Systems Control and Applied Analysis group

Paul Hansch (2022-2026)
Smart Electronic Olfactory System
Photophysics and Optoelectronics group

Marieke Heidema (2022-2026)
Learning in memristive electrical circuits
Systems and Control Theory Research group

Ruben Hamming Green (2021-2024)
Combined volatile/non-volatile memristive ferroelectric arrays.
Nanostructures of Functional Oxides group & IBM Research-Zurich

Fabian IJpelaar (2022-2026)
Qualitative modeling, simulation and exploration of multi-phenomenal materials dynamics
Computing in Cognitive Materials group

Foelke Jansen (2022-2026)
Qualitative modeling, simulation and exploration of multi-phenomenal materials dynamics (Q-Mat)
Nanostructured Materials and Interfaces group

Jesse Luchtenveld (2021-2025)
Analogue phase-change memory cells for neuromorphic computing
Nanostructured Materials and Interfaces group & IBM Research-Zurich

Tony Juny Pina (2022-2026)
Smart Electronic Olfactory System
Bio-inspired systems and circuits group

Jordi Timmermans (2022-2026)
'Nb-doped $SrTiO_3$ memristive interfaces for Bio inspired Computing'
Artificial Intelligence group

Associated PhD students and Postdocs

Below, we list the PhD students that are funded by other means but whose work is closely related to CogniGron and who take part in CogniGron activities.

Mart Salverda (2015-2019)
Neuromorphic phenomena in thin film perovskite oxides
Nanostructures of Functional Oxides group

Wytse Talsma (2016-2020)
Neuroplasticity in neural networks utilising semiconducting single-walled carbon nanotube inks
Photophysics and Opto-Electronics group

Sanne Berg (2018-2022)
Self-assembled networks of functional metal oxides for neuromorphic materials
Nanostructures of Functional Oxides group

Silvia Damerio (2018-2021)
Thin films of modulated multiferroic oxides as adaptable systems for cognitive computing
Nanostructures of Functional Oxides group

Philipp Klein (2018-2022)
Learning in neuromorphic systems
Bio-inspired Circuits and Systems group - external PhD student (employed at Bielefeld University, Germany)

Alexander Kugele (2018-2022)
Event-based vision for automated driving
Bio-inspired Circuits and Systems group - external PhD student (employed at Bielefeld University, Germany)

Dr. Pavan Nukala (2018-2020)
Multiscale investigations on Si-integrable Ferroelectric Hafnia-Zirconia systems (FERHAZ) – This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie Actions Individual Fellowship grant agreement no. 794954
Nanostructures of Functional Oxides group

Thorben Schoepe (2018-2022)
Neuromorphic sensorimotor systems
Bio-inspired Circuits and Systems group - external PhD student (employed at Bielefeld University, Germany)

Dr. Cynthia Quinteros (2018-2020)
Exploration of ferroic domain walls assemblies in BiFeO3 for neuromorphic implementations – This project has received funding from the European Union Horizon 2020 Research and Innovation action MSCA-RISE-MELON (No. 872631)
Nanostructures of Functional Oxides group

Dr. Celestine Lawrence (2020-2023)
Theory of neuromorphic computing – This project has received funding from the EU Horizon 2020 Research and Innovation programme under grant agreement no. 871371
Computing in Cognitive Materials group

Mian Li (2020-2024)
Morphological image analysis of conduction maps – This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 861153
Scientific Visualization and Computer Graphics group

Michele Mastella (2020-2024)
Neuromorphic embedded processing for touch – This project has received funding from the European Research Council (ERC) under grant agreement no. 813713
Bio-inspired Circuits and Systems group

Guillaume Pourcel (2020-2024)
Theory of neuromorphic computing – This project has received funding from the EU Horizon 2020 Research and Innovation programme under grant agreement no. 871371
Computing in Cognitive Materials group

Steven Abreu (2020-2024)
Theory of neuromorphic computing – This project has received funding from the EU Horizon 2020 Research and Innovation programme under grant agreement no. 871371
Computing in Cognitive Materials group

Ole Richter (2020-2024)
Neuromorphic integrated systems for network stability and homeostasis
Bio-inspired Circuits and Systems group

Jan Rieck (2020-2024)
Memristor networks from self-assembled domain walls in oxides – This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 861153
Nanostructures of Functional Oxides group

Willian Soares Girão (2020-2024)
Neuromorphic circuits for novel devices – This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 861153
Bio-inspired Circuits and Systems group

Bhavana Ballal (2021-2025)
Design and development of novel CMOS hybrid circuits for neuromorphic applications
Bio-inspired Circuits and Systems group

Davide Cipollini (2021-2025)
Adaptive random non-linear mappings for neural computing in ferroelastic films – This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 861153
Artificial Intelligence group

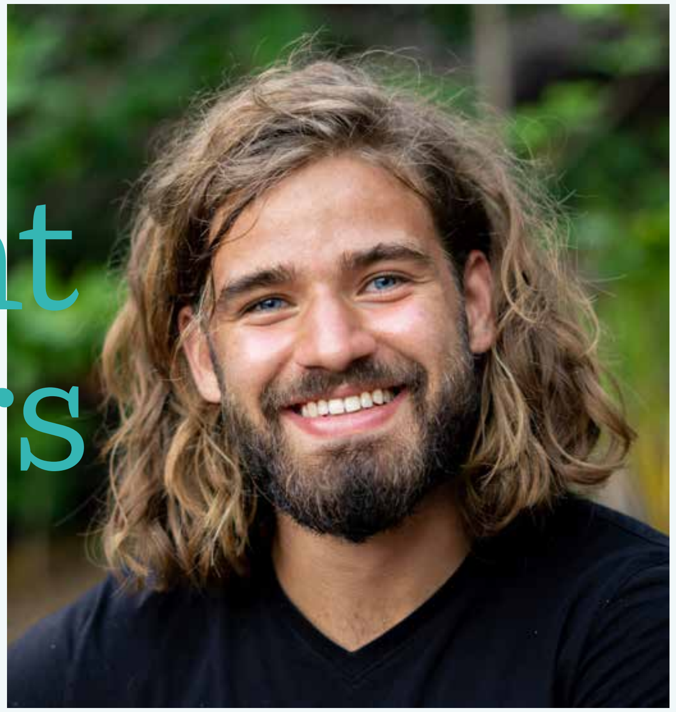
Madison Cotteret (2021-2024)
Neuromorphic memristive VLSI architectures for cognition
Bio-inspired Circuits and Systems group

Maxim Fabre (2021-2025)
On-chip training on analog circuits with memristive devices and bio-plausible learning algorithms
Bio-inspired Circuits and Systems group

Hugh Greatorex (2021-2025)
Memristive time difference encoder
Bio-inspired Circuits and Systems group

Working towards intelligent computers

Photography of Steven Abreu taken by Clara Leopassi.



by Steven Abreu

Computers are everywhere: in our pockets, in our offices and in our cars. At CogniGron, Steve Abreu is designing programming methods for neuromorphic computers. Below, he describes why brains are more intelligent than computers.

Over the past years, some computers have become increasingly "intelligent". More than 20 years ago, IBM's Deep Blue computer beat Garry Kasparov at chess. Six years ago, Google's AlphaGo system beat Lee Sedol at the game of Go. Two years ago, OpenAI's GPT-3 system wrote an article about AI being harmless to humans in The Guardian. The article was edited by a human editor, but the content was generated by GPT-3. Since this year, the power of these tools is known widely thanks to Chat-GPT. Evidently, progress in artificial intelligence has been incredibly fast and impressive.

Brain versus computer

And yet, we still don't have self-driving cars. We still don't have walking-and-talking robots to help us in our everyday lives. Why is that? In my PhD research at the Bernoulli Institute, I work on advancing AI with novel computers. This line of research leads to deep questions, not just about technology but also about the nature of intelligence itself. What is limiting progress in AI? Why are brains more intelligent than our computers?

'Wetware' instead of hardware

First of all, it is important to realize that artificial intelligence is really quite different from human intelligence. The difference is not surprising. AI runs on digital hardware, which processes digital information step-by-step according to programmed rules, or algorithms. Human intelligence runs on biological "wetware" which processes information simultaneously in billions of neurons, according to physical dynamics and chemical reactions. If we want to build computers that can drive, walk, and talk, we may want look to the brain for inspiration.

Learning systems

Much of today's progress in AI already comes from deep learning, where models of neural networks are simulated on digital computers. Such models can be trained to learn to perform tasks without being explicitly programmed. This means we can train a deep learning system to recognize different faces without needing to specify how this should be done. However, we are only simulating these neural network models in the same digital hardware that was designed for managing Excel spreadsheets or playing video games. This is slow, energy-consuming, and limits us to neural networks that are much smaller and simpler than the human brain. Conventional computing technologies are facing fundamental limits, which prohibit us from designing and training larger neural networks. Therefore, we must look to new kinds of computing devices to enable us to scale to larger and better AI systems.

"If we want to build computers that can drive, walk, and talk, we may want look to the brain for inspiration."

Neuromorphic Computers

Neuromorphic computers take inspiration from how the brain processes information by building computers made of neural networks directly in the physics of the device. Building physical neural networks into our computers makes neural computation more energy efficient and allows for more accurate modeling of neural dynamics. Neuromorphic chips can be manufactured using the same materials we use for digital computer chips, but in the new CogniGron center at the UG novel "cognitive materials" are also being investigated. These materials promise more efficient memory and learning for next-generation computers.

Emulating the brain

There are two main goals of neuromorphic computing. First, by building systems that work like the brain, we can build more powerful and energy efficient computers, which may open the doors for the next generation of artificial intelligence. Second, by building a system that emulates the brain, we improve our understanding of how the brain works and how it gives rise to intelligent behavior. Neuromorphic computing requires a truly interdisciplinary effort, connecting materials scientists, neuroscientists, device engineers, computer scientists, and cognitive scientists under a unifying objective of building brain-like computers.

Programming neuromorphic computers

Why do we still use digital computers and not neuromorphic ones? Digital computers are easily programmable and a single computer can run many different programs. You can use the same computer to receive emails, edit spreadsheets and watch movies. In contrast, programming neuromorphic systems for different tasks is not as easy. As owners of neural networks, we know from experience that we cannot directly tell a neural network what to do (don't think of a pink elephant). Similar difficulties arise when working with neuromorphic computers. We have found ways to program, or train, artificial neural networks on digital computers. But the same methods do not work in analog computers, or in novel cognitive materials. To make neuromorphic computers useful, I aim to develop novel methods for programming them. To achieve this, I work with different neuromorphic computers to design programming methods and training methods within the constraints of the given physical system.

"In a neuromorphic future, each one of us would be able to carry around a personalized intelligent AI in our pocket, without depending on large organizations to process our data."

A new chip

I currently work with the DynapSE2 chip, which was designed by researchers from the Institute of Neuroinformatics in Zurich and the University of Groningen. This analog chip contains 1024 neurons, each of which can be connected with up to 64 other neurons. All neurons process information at the same time, and the chip only consumes energy when information is processed. Standard ways of training neural networks on digital computers cannot be applied on the DynapSE2, so we have to radically re-think how to program, or train, such a computer. The DynapSE2 serves as a testbench for ideas which can eventually be scaled up to larger neuromorphic chips in the future.

Outlook

As a Marie Curie fellow in the European project "Post-Digital", I get to collaborate with colleagues in different research institutions across Europe. Currently, I am on a three-month visit at the Institute of Neuroinformatics in Zurich to collaborate with other researchers on the DynapSE2 chip. Later this year, I will join a research group at the University of Ghent in Belgium to expand my research to optical neuromorphic computers. Optical computers leverage laser technology for optical signals traveling at the speed of light, which is a significant advantage over the much slower transmission of electrical signals in electronic computers.

AI in everyone's pocket

I want my research to contribute to the democratization of AI. At present, large companies that can afford expensive supercomputers have a monopoly on AI models because our laptops and smartphones are not powerful enough. In a neuromorphic future, each one of us would be able to carry around a personalized intelligent AI in our pocket, without depending on large organizations to process our data.

This article was created in collaboration with MindMint.

Governance

This section describes the governance, in which we proudly outline the management structure, that together with the researchers, fuels the vision and success of our research centre. At the heart of our organisation lies a dynamic framework of leadership and oversight, meticulously designed to drive innovation, foster collaboration, and ensure the highest standards of performance. Below the responsibilities of the different entities in the management structure are described. From the timely guidance of our supervisory board to the tireless efforts of our programme board, each facet of our management team synergizes to create an environment of efficiency, and continuous improvement to realise the ambitions and goals of CogniGron.

Scientific Director

At the centre of CogniGron resounding success lies the efforts and vision of the founding scientific director, Prof. Beatriz Noheda. The Scientific Director is responsible for the scientific programme and chairs the Programme Board. The director functions as the official representative of the centre and shapes the cutting-edge scientific programme.

Beatriz Noheda received her PhD in Physics from the Universidad Autónoma de Madrid, Spain. In 2003, after holding various positions at Saarland University, the Clarendon Laboratory in Oxford, Brookhaven National Lab in New York and the Vrije Universiteit in Amsterdam, she was awarded a Rosalind Franklin Fellowship by the University of Groningen, where she is now Full Professor. Noheda is a Fellow of the American Physical Society and recipient of the IEEE Robert E. Newnham Ferroelectrics Award. She has served as a member of numerous national and international committees and several editorial boards. She is the author of more than 150 publications and receives more than 10 invitations a year to speak at international conferences. Noheda's research focuses on understanding the relationship between the structure and functionality of thin films of ferroelectric and multiferroic materials, often used as memory elements. Her research, although fundamental in nature, is inspired by two main application areas that, together, she believes will enable the next technological revolution: piezoelectric energy harvesting for low-power electronics and the development of novel materials for adaptable electronics and neuromorphic computing.

Programme Board

The programme Board steers us toward ground-breaking discoveries. The Programme Board, chaired by the scientific director, are the driving force behind CogniGron's scientific strategy and daily operations. This team allocates the budget, determines the scientific strategy, and is responsible for the daily running of the scientific programme, as well as the recruitment of new staff. It is composed of the following members:

Prof. Beatriz Noheda (chair)
Professor Nanostructures of Functional Oxides

Prof. Tamalika Banerjee
Professor Physics of Nanodevices

Prof. Georgi Gaydadjiev
Professor Innovative Computer Architectures

Prof. Maria Antonietta Loi
Professor Photophysics and Optoelectronics

Prof. Lambert Schomaker
Professor Artificial Intelligence

Dr. Alef Sterk
Assistant Professor Mathematics

Prof. Niels Taatgen
Professor Artificial Intelligence and Chair of the Board of the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence

Prof. Caspar van der Wal
Professor Physics of Quantum Devices and Director of the Zernike Institute for Advanced Materials

Prof. Ton Engbersen - Advisor to the Programme Board
Professor Data Science Engineering

Supervisory Board

The Supervisory Board oversees the long term strategy of the research centre, and advises the scientific director on significant changes in focus and implementation of the programme. It is composed of the following persons:

Drs. Hans Biemans
Member of the Board of the University of Groningen

Prof. Joost Frenken
Dean of the Faculty of Science and Engineering, University of Groningen.

Dr. Esther Marije Klop
Managing director of the Faculty of Science and Engineering, University of Groningen.

Coordinating Office

The Coordinating Office assists the Scientific Director and the Programme Board in all aspects of management, outreach and communication activities. The office is led by Dr. Jasper van der Velde, Scientific Coordinator CogniGron.

Scientific Advisory Panel

CogniGron is proud to have an elite team of researchers to form the international Scientific Advisory Panel. This panel is tasked with advising the Scientific Director and the Programme Board on the scientific merits of research plans and with assisting in delineating new scientific directions.

Prof. Giacomo Indiveri
Professor Neuromorphic Cognitive Systems and Director of the Institute of Neuroinformatics
UZH / ETH Zurich, Switzerland

Prof. Julie Grollier
Professor Nanodevices for Bio-Inspired Computing and Chair of the interdisciplinary research network GDR BioComp
CNRS/Thales, France

Dr. Heike Riel
IBM Fellow, Department Head Science & Technology
IBM Zurich, Switzerland

Prof. Ivan Schuller
Professor Nanoscience and Director of QMEENC (Quantum Materials for Energy Efficient Neuromorphic Computing)
Department of Physics and Centre for Advanced Nanoscience, University of California, San Diego, USA

Prof. Rainer Waser
Professor of Electrical Engineering and Information Technology at RWTH Aachen University, Germany, and Director of the Peter Grünberg Institute, Julich, Germany

Prof. Yoeri van de Burgt
Assistant Professor in Microsystems group
Institute of Complex Molecular Studies (ICMS), TU Eindhoven, Netherlands

Prof. Wilfred van der Wiel
Professor of Nano Electronics and Director of the Centre for Brain-Inspired Electronics (BRAINS)
University of Twente, Netherlands

Prof. Chris Eliasmith
Professor Philosophy and Systems Design Engineering, and cross-appointed to Computer Science and Director of the Centre for Theoretical Neuroscience
University of Waterloo, Canada

Prof. Susan Stepney
Professor of Computer Science
University of York, United Kingdom


BERNOULLIBORG

New Staff

CogniGron has been an interdisciplinary programme by choice, as summarized in Figure 1. In the past years, twelve new professor positions were created to increase the synergy between disciplines. These new staff members will further bolster interaction between our experts in materials science, AI, mathematics and computer science. Selecting these new colleagues has been one of the main focuses of CogniGron since its official start.

We are delighted to report that highly talented staff have already been appointed for several of these positions, and have started working in Groningen. They are introduced below (in reverse chronological order of their appointments):

Dr. Julian Koellermeier

Computational Mathematics group

Julian Koellermeier has been appointed as Assistant Professor in Computational Mathematics at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence within CogniGron. His position has been designed to bridge the gap between mathematics, computer science and artificial intelligence. Koellermeiers research focuses on modelling, analysis, and numerical simulation of fluid dynamical PDEs with applications in atmospheric re-entry, hypersonic flows, and free surface flows. He is also well versed in stochastic PDEs, control, and UQ. An expertise that is a very valuable addition to CogniGron where mathematical models, numerical simulations, UQ, and control problems are ubiquitous

Koellermeier obtained his PhD in Computational Mathematics at RWTH Aachen in 2017. After a two-year joint postdoctoral scholarship at Free University Berlin and Peking he moved to NUMA group at KU Leuven as a University Marie-Curie postdoctoral fellow. Thus far he obtained 7 scholarships, among them 2 by the German National Academic Foundation, together with 8 awards, including an award medal for graduation with distinction from RWTH Aachen University.

Dr. Gilles Bonnet

Stochastics research group

Gilles Bonnet has been appointed as Assistant Professor in Stochastics at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence within CogniGron. Performing research at the crossroads of probability theory and convex geometry, his position has been designed to bridge the gap between mathematics, material science, computer science and artificial intelligence. Bonnet investigates properties of random geometric structures, such as random convex hulls, cells of random tessellations (Voronoi, Delaunay and hyperplane tessellations) and Poisson Delaunay graphs. Within the context of CogniGron his research on tessellations can be used as good models for materials, and random geometric graphs can be the basis for studying (random) electrical networks for example.

Bonnet obtained his Bachelor's (2007) and Master's (2009) degrees in Mathematics at the University of Bordeaux (France). During the first year of his Master's he was an Erasmus student at the University of Manchester (UK). In Bordeaux he also passed the Capes and Agrégation examinations, which are French competitive examinations to become a teacher. It led him to teach mathematics in Paris for two years (2010-2012). Afterwards he studied for one year at the University of Barcelona (Spain), where he obtained a second Master's degree (2013) with a thesis in the field of tropical geometry. Then he decided to do a PhD at the University of Osnabrück (Germany) under the supervision of Professor Matthias Reitzner. His doctoral thesis (2016) was about the Poisson hyperplane tessellation. After that, Bonnet was a postdoc at the University of Bochum (Germany) in the group of Prof. Christoph Thäle. In 2021 he was appointed at the University of Groningen.

Dr. Revantha Ramanayake

Theory of Computation research group

Revantha Ramanayake has been appointed as Assistant Professor in Theory of Computation at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, within CogniGron. His position has been designed to bridge the gap between mathematics, computer science and artificial intelligence. Ramanayake's area of expertise is proof theory and logics in computer science. He investigates various families of reasoning such as substructural, modal and fuzzy logics, their (meta) logical and proof-theoretic properties, and their application in computer science and mathematics. He is also interested in the use of proof assistants for the formal verification of proofs. As part of CogniGron, he will investigate the computational properties of neuromorphic computing systems, as well as the use of formal logical methods to study such systems.

Ramanayake studied Mathematics at the Australian National University, where he obtained his PhD in theoretical computer science/logic in 2011. From 2011-2012 he was a postdoctoral researcher at the Laboratoire d'Informatique of the École Polytechnique (France). Subsequently, he was a (senior) postdoctoral researcher at the TU Wien (2012-2020) and at the Wolfgang Pauli Institute (Austria). Within this period, he headed an Austrian Science Fund grant on unifying logical frameworks in proof theory. He commenced at Groningen in March 2021.

Prof. Elisabetta Chicca

Bio-inspired Circuits and Systems research group

Elisabetta Chicca has been appointed as Professor Bio-inspired Circuits and Systems at the Zernike Institute for Advanced Materials within CogniGron. Her position has been designed to bridge the gap between material science, computer science and artificial intelligence. She aims to identify the principles of neural computation and implement them in fully parallel and low-power neuromorphic systems that offer the opportunity to overcome the limitations of traditional digital architectures. Hereby she develops biologically inspired learning, sensing and acting systems, which allow to test current theories of neural computation. The physical substrate of these implementations consists of CMOS technology and novel materials.

Chicca obtained a "Laurea" degree (MSc) in Physics from the University of Rome 1 "La Sapienza", Italy in 1999, a PhD in Natural Science from the Swiss Federal Institute of Technology Zurich (ETHZ, Physics department) and in Neuroscience from the Neuroscience Centre Zurich, in 2006. Chicca has carried out her research as a Postdoctoral fellow (2006-2010) and as a Group Leader (2010-2011) at the Institute of Neuroinformatics (University of Zurich and ETH Zurich) working on development of neuromorphic signal processing and sensory systems. From 2011 to 2020 she led the Neuromorphic Behaving Systems research group at Bielefeld University (Faculty of Technology and Cognitive Interaction Technology Centre of Excellence, CITEC). Since 2020 she leads the Bio-inspired Circuits and Systems research group in Groningen. Her current interests are in the development of VLSI models of cortical circuits for brain-inspired computation, learning in spiking VLSI neural networks and systems based on memristive devices, bio-inspired sensing (olfaction, active electrolocation, audition, visually guided navigation) and motor control.

Prof. Boris Koldehofe

Computer Networks group

Boris Koldehofe has been appointed as Professor in Computer Networks at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, within CogniGron. His position has been designed to bridge the expertise gap between mathematics, computer science and Physics. His research contributes to mechanisms and methods for distributed and self-adaptive intelligent systems. This comprises methods and mechanisms that i) account for today's tremendous data volumes, ii) help utilize resources like the network infrastructure and processing resources efficiently, iii) provide information in a consistent and reliable way, and iv) account for several constraints such as privacy of information and quality of data/service.

Koldehofe obtained a Diplom in Informatik at the Universität des Saarlandes, Saarbrücken, Germany in 1999. In 2003, he obtained a Licentiate of Philosophy degree at Chalmers University of Technology, Göteborg, Sweden, where he also received his PhD degree in 2005. Koldehofe carried out his postdoctoral research (2005-2006) at the Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland. Afterwards he became a senior researcher and lecturer at the Institute for Parallel and Distributed Systems (IPVS) at Universität Stuttgart, Germany, where he headed the Adaptive Communication Systems research group until 2014. From 2014 to 2020 he was appointed as senior researcher and lecturer in the Multimedia Communications Lab (KOM) at the Technische Universität Darmstadt, Germany. Since 2017 he was also the Principal Investigator of the DFG Collaborative Research Centre 1053 MAKI. In 2020, Koldehofe was appointed in Groningen to lead the computer networks research group. His current interests are networked and distributed systems, middleware and event-based systems.

Prof. Georgi Gaydadjiev

Computer Architectures group

Georgi Gaydadjiev has been appointed as a Full Professor in Innovative Computer Architectures at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence within CogniGron. His position has been designed to bridge the expertise gap between artificial intelligence and computer science. Gaydadjiev is a Computer Engineer with over 30 years of industrial and academic experience. He has worked on various designs of embedded systems (even before such systems were given this name). He also performed research on computer architectures and microarchitectures for reconfigurable, highly customized and safety-critical computing systems. His current research focus is on advanced (digital and non-digital), highly customized computing systems, based on cognitive materials and devices.

Gaydadjiev obtained his degree in control systems engineering at Voenmeh (currently the Baltic State Technical University) in Leningrad, Soviet Union, and subsequently worked designing personal computer I/O peripherals at System Engineering Ltd in Pravetz (Bulgaria). He later joined Pijnenburg Microelectronics and Software in Vught, the Netherlands, working on various designs of embedded systems. While working at Pijnenburg M&S, he also enrolled at TU Delft and successfully completed a Master's in Electrical Engineering. In 2002, Georgi joined the Computer Engineering laboratory at the Faculty of Electrical Engineering, Mathematics and Computer Science of TU Delft. His research was funded by STW, the European Commission, point.one, CenterNovem/BSIK and Google Inc. In 2011, he received a personal grant from the Swedish Research Council (VR) and joined Chalmers University of Technology, holding the professorial chair in Computer Systems Engineering. In 2014, he joined Maxeler Technologies Ltd in London, an appointment that led to the creation of Maxeler IoT-Labs BV in Delft. At Maxeler, Gaydadjiev led the Dataflow Software Engineering division as one of the company's vice presidents and focused on the research and development of highly customized high-performance computing (HPC) systems. Some of these systems were able to outperform TOP-500 supercomputers in very specific tasks while using only a fraction of the electrical energy required. In August 2019, Gaydadjiev moved to Groningen.

Prof. Herbert Jaeger

Computation in Cognitive Materials group

Herbert Jaeger has been appointed as a Full Professor in Computation in Cognitive Materials at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence within CogniGron. His position has been designed to bridge the expertise gap between artificial intelligence, computer science and materials science. Jaeger is internationally recognized for pioneering the field of 'reservoir computing' (RC). In this non-standard approach to computer chip design, computing can be non-digital and does not necessarily use transistors as basic computing elements. Instead, a randomly structured lump of nonlinear material (possibly nanoscale) is used as a 'reservoir' of dynamic phenomena. The input data are fed into this material reservoir and 'excite' high-dimensional response dynamics within it, from which the desired output is distilled with machine learning methods. This can be done not only with electrical forms of input signals, but also with optical, chemical, mechanical or magnetic signals, or mixtures thereof. Due to this universality, and also because there are fascinating similarities with how biological brains work, RC has become an important approach to making computing more 'cognitive' and also more energy-efficient than is possible with standard digital hardware. Jaeger's quest to model 'cognitive' information processing systems has led him to classical AI, robotics, signal processing, computational neuroscience, machine learning and neuromorphic computing. In all of these fields, he aims to find mathematically beautiful descriptions and efficient modelling/learning algorithms. Within CogniGron, he helps create mathematical/algorithmic bridges between AI, machine learning, computer science, mathematics, materials science and neuroscience. This means developing new 'cross-cultural' formalisms and models, a wonderful challenge both for the most abstract theoretical/conceptual process of thinking, as well as for the most concretely useful algorithm design.

Jaeger studied Mathematics and Psychology at the University of Freiburg and obtained his PhD in Computer Science (Artificial Intelligence) at the University of Bielefeld in 1994. After a five-year postdoctoral fellowship at the German National Research Centre for Computer Science (Sankt Augustin, Germany) he headed the Intelligent Dynamical Systems group at the Fraunhofer Institute for Autonomous Intelligent Systems AIS (Sankt Augustin, Germany). In 2003, he was appointed Associate Professor for Computational Science at Jacobs University Bremen, where he led the Modelling Intelligent Dynamical Systems (MINDS) group until his CogniGron appointment as Professor of Computing in Cognitive Materials on 1 August 2019.

Prof. Bart Besselink

Engineering Mathematics group

Bart Besselink has been appointed as an Assistant Professor in Engineering Mathematics at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, within CogniGron. His position has been designed to bridge the expertise gap between mathematics and materials science. Besselink's research interests are in the analysis and control of large-scale dynamic systems with emphasis on nonlinear systems and model reduction problems. Currently, he focuses on the development of modular techniques for the analysis and control of such systems, including the analysis of large-scale electrical circuits with nonlinear elements such as memristors. Memristive devices are regarded as promising elements for cognitive computing as, first, they have dynamics that make them suitable for acting as synapses in artificial neural networks and, second, they have natural nanoscale implementations in specific materials. Within CogniGron, this research line targets the analysis of large-scale electrical circuits with memristive elements as models of neuromorphic materials, with the aim of understanding material behaviour as well as guiding the design of material network structures. Such analysis requires the development of novel mathematical tools to analyse the robustness of electrical circuit behaviour with respect to non-uniformity in the electrical components, then to synthesize the desired behaviour, and finally, study the scalability of such networks.

Besselink received his MSc and PhD degrees in Mechanical Engineering from Eindhoven University of Technology, the Netherlands, in 2008 and 2012, respectively, both with a focus on systems and control theory. He was a short-term visiting researcher at Tokyo Institute of Technology, Japan, before becoming a postdoctoral researcher at the ACCESS Linnaeus Centre and Department of Automatic Control at KTH Royal Institute of Technology, Stockholm, Sweden, between 2012 and 2016.

Prof. Davide Grossi

Cognitive Multi-Agent Systems group

Davide Grossi has been appointed as an Associate Professor in Multi-Agent Decision-making at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence within CogniGron. His position has been designed to bridge the expertise gap between artificial intelligence and computer science. He works on foundational topics in artificial intelligence and multi-agent systems. His main research focus concerns the question: How do different autonomous (human or artificial) entities make good decisions as groups? Examples of processes of this type are elections, referenda, deliberative committees and assemblies, information markets and consensus protocols. Grossi currently explores whether tools from computational economics (e.g., game and social choice theory, network theory) can be used to gain insights into how groups of relatively simple entities (e.g., neurons) can (self-)organize to support computational processes.

Grossi obtained his degree in Philosophy (with distinction) at the University of Pisa and obtained his PhD in Computer Science at the University of Utrecht in 2007. After undertaking postdoctoral research at the University of Luxembourg and the University of Amsterdam, he became a lecturer (Assistant Professor) in the Department of Computer Science at the University of Liverpool, where he was promoted to senior lecturer (Associate Professor) in 2015. In 2017, he was appointed Associate Professor at the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, within CogniGron. Grossi has authored over 60 peer-reviewed articles published in international journals and presented at international conferences, including top-tier journals and conferences in artificial intelligence. He has been the recipient of grants from research agencies in the UK (EPSRC) and the Netherlands (NWO), among other countries.

Outlook to 2023

CogniGron is pleased to announce that Matthew Cook and Erika Covi are joining our team in 2023. Their broad expertise and passion for neural architectures and information processing make them an excellent addition to our team. CogniGron is looking forward to the insights and ideas they will bring.

Matthew Cook

Matthew Cook comes to CogniGron with ample industrial and academic experience obtained at Wolfram Research, Caltech and ETH Zurich. During his career, he has established himself as a leader in in the field of neural architectures for neural information processing. He has a proven track record of success in neuromorphic engineering and connectomics. His work on the link between the deep-network algorithms used in machine learning and the spiking neural networks used to implement neuromorphic computing systems, have had a major impact in the field, and his ground-breaking work on relational networks provides a framework for linking detailed low-level biologically plausible neural network architectures to high-level cognitive and behavioral models.

In his new role at CogniGron, Matthew Cook will establish a new research direction in Groningen and will work closely with our teams in materials science, artificial intelligence, mathematics and computer science. His expertise will be invaluable to our organization as we continue to do fundamental research into self-learning materials and systems for cognitive computing – computing that has the ability to learn and to handle complex challenges in a highly efficient way, inspired by how the brain works. Our mission: to find a new blueprint for future-proof computing.

Erika Covi

Erika Covi is currently a tenured researcher at the National Research Council of Italy (CNR) on leave at NaMLab gGmbH, Dresden (Germany), where she is working as a ERC Group Leader. Her research interests lie at the intersection of circuit design, emerging devices, and brain-inspired computing.

Erika Covi is a young talented researcher that has a track record and experience in promising topics such as emerging memories, memristive devices, circuit design, and neuromorphic/in-memory computing, that have become very strategic in the last few years. In her new role at CogniGron she will set up a new research direction in Cognitive Devices, working closely with the Bio-inspired Circuit and Systems team, and strengthening the bridge between the material science and physics groups and the, artificial intelligence and computer science groups. Her expertise is currently not present in Groningen and we are very much looking forward welcoming her and join our goal to develop a one-of-a-kind Neuromorphic Chip.

Research Projects

Cross-Disciplinary PhD Projects

Staff can participate and contribute to the CogniGron research programme by having a PhD student funded via this programme. A requirement is that staff and team members fully commit to the scientific goals and work plan of CogniGron. In addition, projects that strengthen the collaboration between different disciplines are prioritized. A 4-page proposal is submitted for each PhD. The proposal should clarify how the research directly addresses the main goals of CogniGron and how it will contribute solutions beyond the state of the art. In addition, the proposal should explain how it will make use or enhance the collaboration between different disciplines/institutes. The proposals are reviewed by the CogniGron Program Board and, if needed, by the Scientific Advisory Panel composed of external experts.

Running projects awarded in 2022:

Robust Learning of Sparse Representations: Brain-inspired Inhibition and Statistical Physics Analysis
Sparsity is among the key factors that contribute to high energy efficient processing in the brain. Neuroscientists believe that inhibition is a crucial property that results in sparse and thus highly energy efficient representations. Sparsity and inhibition are the focus of this project, consisting of two key objectives: the investigation of push-pull inhibition embedded in convolutional and spiking neural networks, and the systematic study of learning processes in model situations.

Project leaders; George Azzopardi and Michael Biehl

Memristive models for faster material design cycles towards applications
Long development cycles for memristive devices and materials are inhibiting innovation due to large parameter spaces, complex manufacturing processes, and necessary measurement series. This limits physical insight, performance, and applications of memristors. The project tackles this challenge by a close interaction of mathematical modeling and material science, in which newly acquired experimental data and models from material scientists are used in a closed design loop together with state-of-the-art mathematical techniques. The goal of this project is to combine mathematical and material models to improve understanding of memristive materials, speedup memristor design, and extend memristors' application areas.

Project leaders: Tamalika Banerjee and Julian Koellermeier

Running projects awarded before 2022:

Smart Electronic Olfactory System (awarded in 2021)
The use of so-called electronic noses has spread widely in many industrial sectors thanks to their ability to detect chemicals in very small concentrations. In the health-care sector, this technology is starting to play a key role as a rapid and low-cost diagnostic tool for many diseases. In this project we are specifically interested in the development of an electronic noses for lung cancer detection.

Project leaders: Elisabetta Chicca, Maria Loi and Alden Waters.

Qualitative modelling, simulation and exploration of multi-phenomenal materials dynamics (awarded in 2021)
Current approaches to computing based on digital hardware have limitations and call for novel alternatives. The aim of this project is to pioneer a new qualitative physics formalism, together with a qualitative physics engine that is able to simulate a wide range of phenomena while being fast to run, replacing numerical accuracy by qualitative validity.

Project leaders: Herbert Jaeger and Beatriz Noheda

Nanoparticle based percolating networks towards neuromorphic computing (awarded in 2020)
Nanoparticle percolating networks exhibit interesting switching behaviour and potentiation, which are characteristics of the brain with neurons and synapses. In this project, phase change material nanoparticles are designed, synthesised and mathematically modelled. These materials are expected to have a richer network activity and therefore excellent materials used for neuromorphic computing.

Project leaders: George Palasantzas, Bart Kooi, Holger Waalkens and Daniel Valesin

Nb-doped SrTiO3 memristive interfaces for bio-inspired computing (awarded in 2019)
This project studies the physics of interface-based memristive devices on semiconducting SrTiO3 substrates and develops phenomenological models to predict the performance of such devices.

Project leaders: Tamalika Banerjee and Lambert Schomaker

Towards a cognitive computer architecture based on memristive devices: developing short- and long-term memory (awarded in 2019)
The goal of this project is to build a pattern-completion memory, which we believe is a critical component in developing novel cognitive computing architectures. We will accomplish this by building a neural network in which memristive devices act as synapses, and potentially also as soma. One of the two sub-projects focuses on the development of networks, while the other focuses on the materials.

Project leaders: Niels Taatgen, Tamalika Banerjee and Jelmer Borst

WALLNET: Memristor networks from self-assembled domain walls in oxides (awarded in 2019)
This project investigates materials that self-organize in conducting networks that can transmit signals and host memory elements in a similar way to biological neurons and synapses.

Project leaders: Bart Besselink, Beatriz Noheda and Arjan van der Schaft

CogniGron Fellowships

Staff can also participate and contribute to the CogniGron research programme through a PhD student who works in close collaboration with external partners, preferably industry partners with a strong track record or interest in cognitive systems and materials. The goal of these CogniGron Fellowships is to strengthen interaction with industry. Additionally, it will give the PhD student the opportunity to take an inside view and collaborate with a world-leading industrial partner on cognitive computing. The primary supervisor will hold a position at the Faculty of Science and Engineering and the PhD degree will be awarded by the University of Groningen.

CogniGron-IBM Fellowships

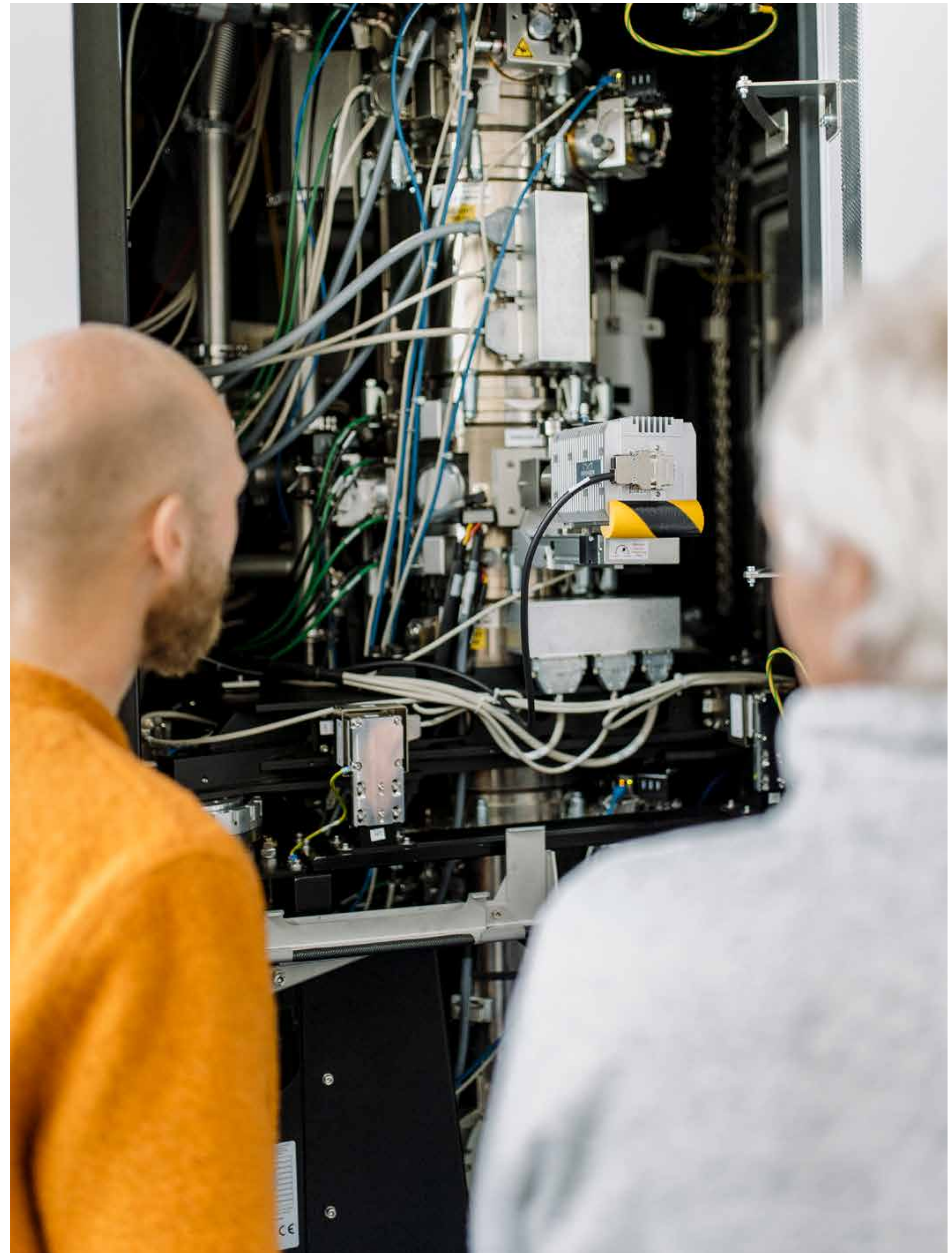
Two CogniGron-IBM fellowships have been awarded. CogniGron has partnered with IBM in these projects to work on novel materials for neuromorphic computing.

COFERRAY: Combined volatile/non-volatile memristive ferroelectric arrays
The project aims to develop synaptic devices, like in the brain, based on ferroelectric materials. In particular, the goal is to build arrays of these (memristive) devices that can show both short-term and long-term potentiation and depression, which is important for the implementation of neural networks.

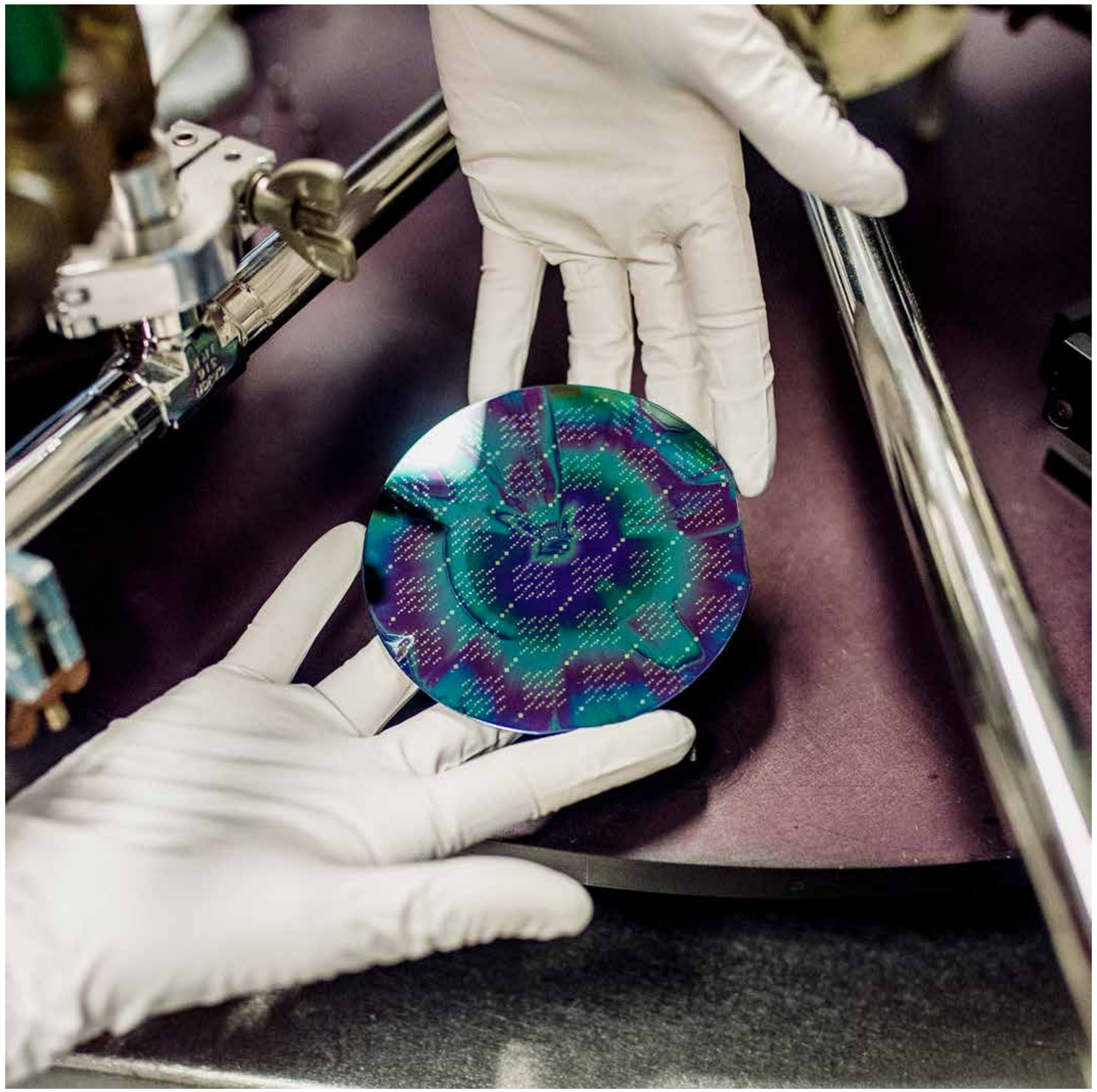
Project leaders: Beatriz Noheda (CogniGron), Sigi Karg and Bert Offrein (IBM-Research Zurich)

Analogue phase-change memory cells for neuromorphic computing
Phase-change memories are, to date, arguably the most advanced resistive memory technologies. Phase-change memories are also being explored for in-memory computing applications, such as performing logical operations as well as realizing hardware substrates for neuromorphic computing. It has been shown that phase-change memory devices can emulate some of the key synaptic and neuronal functionalities, thus facilitating the realization of ultra-low power and dense neuromorphic hardware. In this project, we propose a relatively new concept of phase-change memory.

Project leaders: Bart Kooi (CogniGron) and Abu Sebastian (IBM-Research Zurich)



Strategic Partnerships



Strategic partnerships play a crucial role in advancing scientific research and technological innovation. CogniGron believes in the power of working together, between different disciplines, but also between different institutions.

University College London and Western Sydney University.

Two of such significant collaboration in the field of neuromorphic computing is with Western Sydney University (WSU) and University College London (UCL). After setting up a formal agreement between the International Centre for Neuromorphic Systems lead by prof. André van Schaik at WSU in 2021, CogniGron has set up an agreement with UCL, more specifically with the team of prof. Tony Kenyon, in 2022.

The partnership with UCL and WSU brings together experts fostering a multidisciplinary approach to address the challenges and potential of neuromorphic computing. These strategic partnerships create a unique opportunity to push the boundaries of neuromorphic computing. Through joint research projects, knowledge sharing, and collaborative initiatives with UCL, WSU we can accelerate the education a new generation of researchers and the development of innovative algorithms, hardware architectures, and applications that leverage the power of neuromorphic computing.

Neurotronics Center at Kiel University

In 2022 we started organizing joint workshops and conferences with the CRC 1461 – Neurotronics research center at Kiel University, lead by Prof. Dr. Hermann Kohlstedt. The CRC "Neurotronics: Bio-inspired Information Pathways" will explore and propel the research of novel hardware technologies as a cornerstone for novel bio-inspired computing architectures paving the way towards an unconventional information processing. They envision impacts in various research fields in science and technology, such as robotics and brain implants.

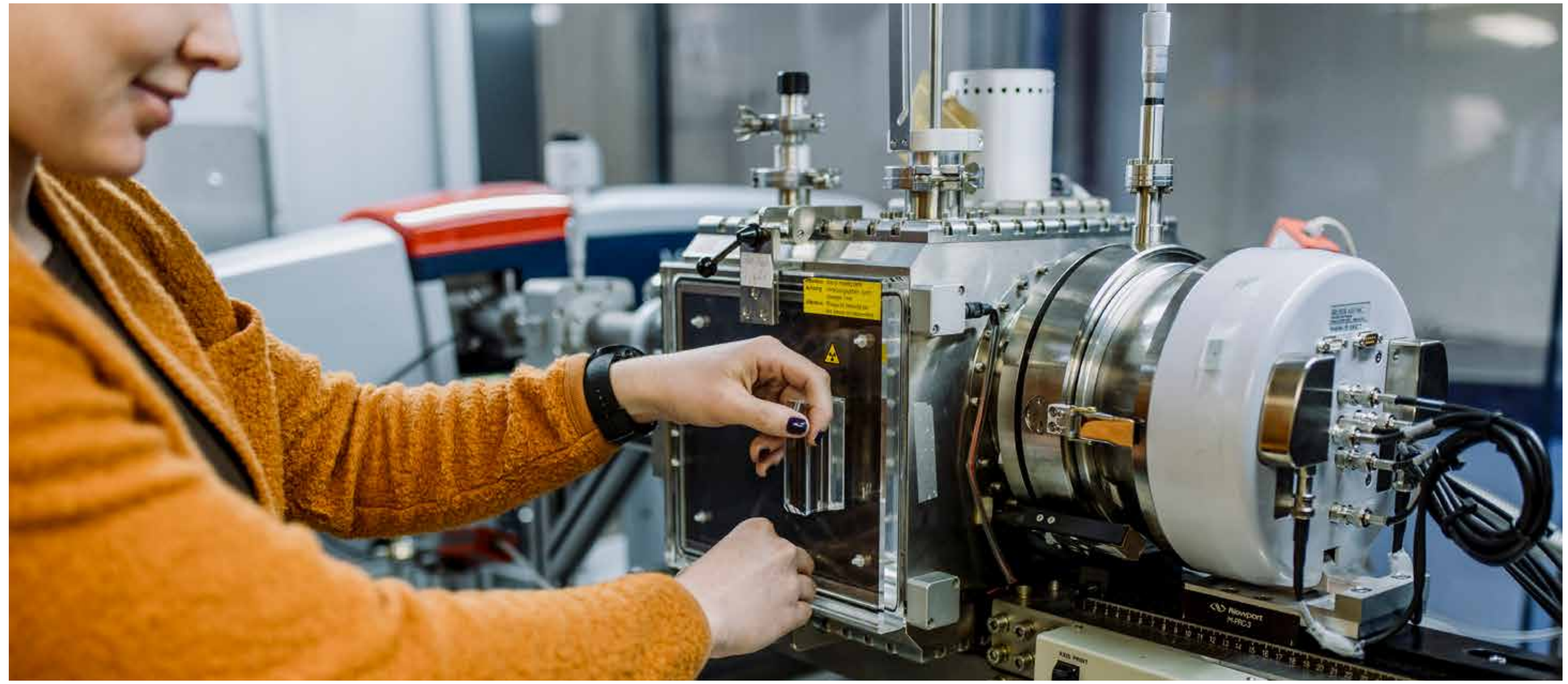
The first joint event we organized was Color Line Workshop on Bio-Inspired Information Pathways. The workshop took place on the ferry betewen Kiel-Oslo-Kiel.

Invited Speakers:

- Andrew Adamatzky, U Bristol, UK
- Simon Brown, University of Canterbury, Christchurch, New Zealand
- Dante R. Chialvo, Universidad Nacional de San Martin, Argentina
- Paschalis Gkoupidenis, MPI Mainz, Germany
- Herbert Jaeger, Groningen University, The Netherlands
- Zdenka Kuncic, University of Sydney, Australia
- Paul Robin, Sorbonne Université, Université Paris-Cité, France
- Wilfred G. van der Wiel, University of Twente, The Netherlands and
- University of Münster, Münster, Germany

In 2023 a second joint event will be organized, namely a PhD Summerschool on brain inspired computing.

Enabling Technologies



CogniGron aims to make fundamental advances towards a disruptive technology, and the efforts in this direction require sophisticated research facilities to synthesize and characterize materials and build devices. These facilities are in large part present at the University of Groningen. However, CogniGron has seen the opportunity to excel by supporting new developments in the form of two advanced research facilities: the electron microscopy centre and NanoLabNL.

Electron Microscopy Centre

The electron microscopy centre of the Zernike Institute for Advanced Materials was founded in 2019 to maintain and provide a coherent and accessible infrastructure for electron microscopy at the University of Groningen. The microscopy centre is made possible by and will primarily be used by the Zernike Institute for Advanced Materials and CogniGron. Electron microscopy is of key importance for the research of CogniGron as it facilitates studying the ultimate origin of memristive behaviour in the materials that will function as artificial (electronic) synapses or neurons. To this end, CogniGron invested (together with the Zernike Institute for Advanced Materials) in the purchase of a new transmission electron microscope (TEM) that allows the study of the structure of materials in unprecedented detail. One of its unique abilities is to produce images of both heavy and very light atoms simultaneously. The purchase also included a second system: a scanning electron microscope, combined with a focused ion beam, which allows scientists to study the general structure of materials (using an electron beam) and extract interesting sections using the ion beam for detailed study in the new TEM. Professor Bart Kooi is primarily responsible for running the new microscope.

NanoLabNL: nanofabrication facilities

NanoLabNL is a national consortium that was created to build, maintain and provide a coherent and accessible infrastructure for nanotechnology research and innovation in the Netherlands. However, with recent funding developments, maintaining the NanoLabNL facility through necessary updates – especially to keep up with developments in other countries in our region – is becoming a challenge.

The long-term stability of NanoLabNL is vital for CogniGron and we believe there is a need for CogniGron and NanolabNL to work together and make sure the facilities are up-to-date with the newest technological advances. Since the goal of CogniGron is closely related to developing novel electronic devices, for which the nanolithography and fabrication facilities provided by NanoLabNL are crucial, CogniGron has reserved funds to support NanoLabNL in the form of a new electron beam evaporator as well as a technician to support the new PhD students and staff who will be using the NanoLabNL facilities in Groningen. We are aware that more support is needed to maintain the NanoLabNL facilities in Groningen at international standards, and we are constantly working with the NanoLabNL management team to find solutions. Therefore, CogniGron has reserved a yearly budget for the running costs of NanolabNL Groningen from 2021 until 2025 and CogniGron researchers can make use of the clean-room facilities at no cost.

CogniGron Activities

Discussion Sessions

One of the keys to a successful research programme is to create sustainable synergy in a unique environment where everyone – from materials scientists to the computer scientists and from artificial intelligence scientists to mathematicians –understands each other's motivations with respect to the common goal. Only then will partnerships arise naturally. This requires to invest in cross-disciplinary education aiming to understand each other's language and concepts.

Therefore, we dedicate considerable effort to organizing brainstorming and discussion sessions of half-day duration, to which all the researchers at the University of Groningen with interests close to CogniGron are invited. In these sessions, which have had various formats, the staff learn about each other's expertise and the first concrete ideas are developed for joint collaborations.

Student Discussion Sessions

Working together with a multidisciplinary team means stepping out of your comfort zone. This is a challenging and time-consuming activity. To facilitate interactions and cross-disciplinary communication, all newly appointed professors work in more than one field and feel comfortable in two or more different worlds. In this respect, we have high expectations of the PhD students working at CogniGron, where they grow up in an inter- and multi-disciplinary environment.

The PhD students will also form the solid foundation upon which the future of CogniGron will be built. CogniGron is, therefore, very happy to see that the students themselves organize weekly meetings with an informal character to discuss their scientific results and scientific challenges they face at the moment, and to keep up to date by discussing literature. Occasionally, they also invite researchers to give a presentation in these meetings.

Education program.
The increasing interest of our new and existing staff towards neuromorphic materials, devices and computers increases is reflected in the education program. Two new courses on core CogniGron subjects have been developed and incorporated in the Applied Physics master curriculum as elective courses: "Neuromorphic circuit design" (given by Elisabetta Chicca) and "Memristive devices' (given by Beatriz Noheda). These have become very popular and are followed not only by regular Applied Physics and Nanoscience master students, but also as elective courses and graduate courses for AI and Computer Science master and PhD students, respectively.

CogniGron@Work Sessions

Being a very new and different initiative, we are aware that we need to make an extra effort to convey our goals and working philosophy to others, including those in our close neighbourhood, as well as to promote the exchange of research progress and ideas. In the CogniGron@work sessions every Monday, researchers from CogniGron explain their work, with a focus on the cross-disciplinary character of the research.

CogniGron Seminars for Invited Speakers

We consider the opportunity to invite experts from around the world to visit Groningen as one of the most important assets of CogniGron. This has been highly advantageous, not only to gain a better understanding of the latest developments in this diverse and emerging field of Cognitive Systems and Materials, but also to create a sense of community, as well as to make CogniGron known to the international and national communities. We are proud of the list of internationally recognized experts who have kindly accepted our invitation and have spent days with us sharing their research ideas and also learning first-hand about the CogniGron vision. In the CogniGron webpages a complete list of speakers is provided, including the titles and dates of their presentations.

Mathias Kläui (University of Mainz, Germany)
"Specialized Talk: Skyrmions in Spin-Orbitronics and Orbitronics – novel science and applications in memory & non-conventional computing"

Tony Kenyon (University College London)
"Materials Challenges for Neuromorphic Electronics" & "Deep learning with memristive devices"

Rodolphe Sepulchre (University of Cambridge, UK)
"Spiking Control Systems"

Erika Covi (NaMLab gGmbH, Dresden, DE)
"Emerging devices for brain-inspired computing: A bridge between materials and circuits and systems"

Thomas Kämpfe (Frauenhofer IPMS, University of Dresden, DE)
"Ferro-Electronics: From Memory to Neuromorphic Computing"

Paschalis Gkoupidenis (Max Planck Inst. for Polymer Research, DE)
"Organic neuromorphic electronics"

Spreading the knowledge and connect

CogniGron takes pride in its role as a catalyst for knowledge exchange and the advancement of the field of neuromorphic computing. In the year 2022, we have successfully organized several international conferences and events, serving as a vibrant platform for researchers, scholars, and experts from around the globe to convene, share their insights, and foster meaningful connections. With a steadfast commitment to excellence, innovation, and interdisciplinary collaboration, we have aimed to create conferences and events that are of exceptional quality, including thought-provoking discussions, that will lead to transformative impact. Below we have summarized the main (inter-)national conferences and/or events organised or co-organized in 2022.

Mini-Symposium: Scaling up Systems and Application Complexity in Analog Neuromorphic and Physical Computing
Groningen (The Netherlands)
24 March 2022.

The field (rather: fields) of neuromorphic / unconventional /physical computing spreads over numerous traditional scientific and engineering disciplines. Learning to understand each other's terminology, motivations, standard working routines and formal methods is as difficult as it is crucial for a long-term productivity of this field (rather: fields…). This needs time. Time for just talking with each other. With regards to this symposium we decided to have only a relatively small number of presentations (the four invited talks) which gives us more time than usual to "just talk" with each other – in moderated discussion rounds and maybe even more importantly, in uncommonly long breaks.

Organiser:
Herbert Jaeger
(CogniGron, University of Groningen)

NanoGe International Conference on Materials, devices and systems for neuromorphic computing
Groningen (The Netherlands)
from 28th to 29th of March 2022
and online.

The goal of this conference was to bring together leading researchers in neuromorphic computing to present new research and develop new collaborations in the area of novel materials, devices and systems for neuromorphic computing. This conference presented an overview of the recent insights into the desired properties of materials and devices for brain-inspired computing. Here not only memristor based architectures will be discussed, but also CMOS or hybrid based architectures. In addition, the conference had session on sensing and learning of physical systems as this is an important part in the development of neuromorphic computing and to bridge the gap between materials and devices and applications, including brain machine interfaces. Key showcases of novel neuromorphic materials and devices will be highlighted in relation to applications within industry.

Organisers:
Beatriz Noheda
(CogniGron, University of Groningen)
Elisabetta Chicca
(CogniGron, University of Groningen)
Yoeri van de Burgt
(Eindhoven University of Technology)
Jasper van der Velde
(CogniGron, University of Groningen)

International Workshop "Bio-Inspired Information Pathways"
Colorline Ferry (Kiel-Oslo-Kiel)
from 5th to 8th of September

The International Workshop jointly organized by CogniCron, Groningen and the CRC 1461 Neurotronics at CUA University (Kiel, Germany), to foster the collaboration between researchers and future perspectives Bio-Inspired Information technologies.

The meeting had invited talks from researchers from all over the globe and with various different backgrounds, including physics, chemistry, mathematics, electrical engineering, materials science, machine learning, computer engineering, neuroscience, etc.

Organisers:
Hermann Kolhsted
(CAU, Kiel University)
Sonja Reich
(CAU, Kiel University)
Beatriz Noheda
(CogniGron, University of Groningen)
Jasper van der Velde
(CogniGron, University of Groningen)

Brainspiration 2022
Twente (The Netherlands) from 12th to 14th of October 2022

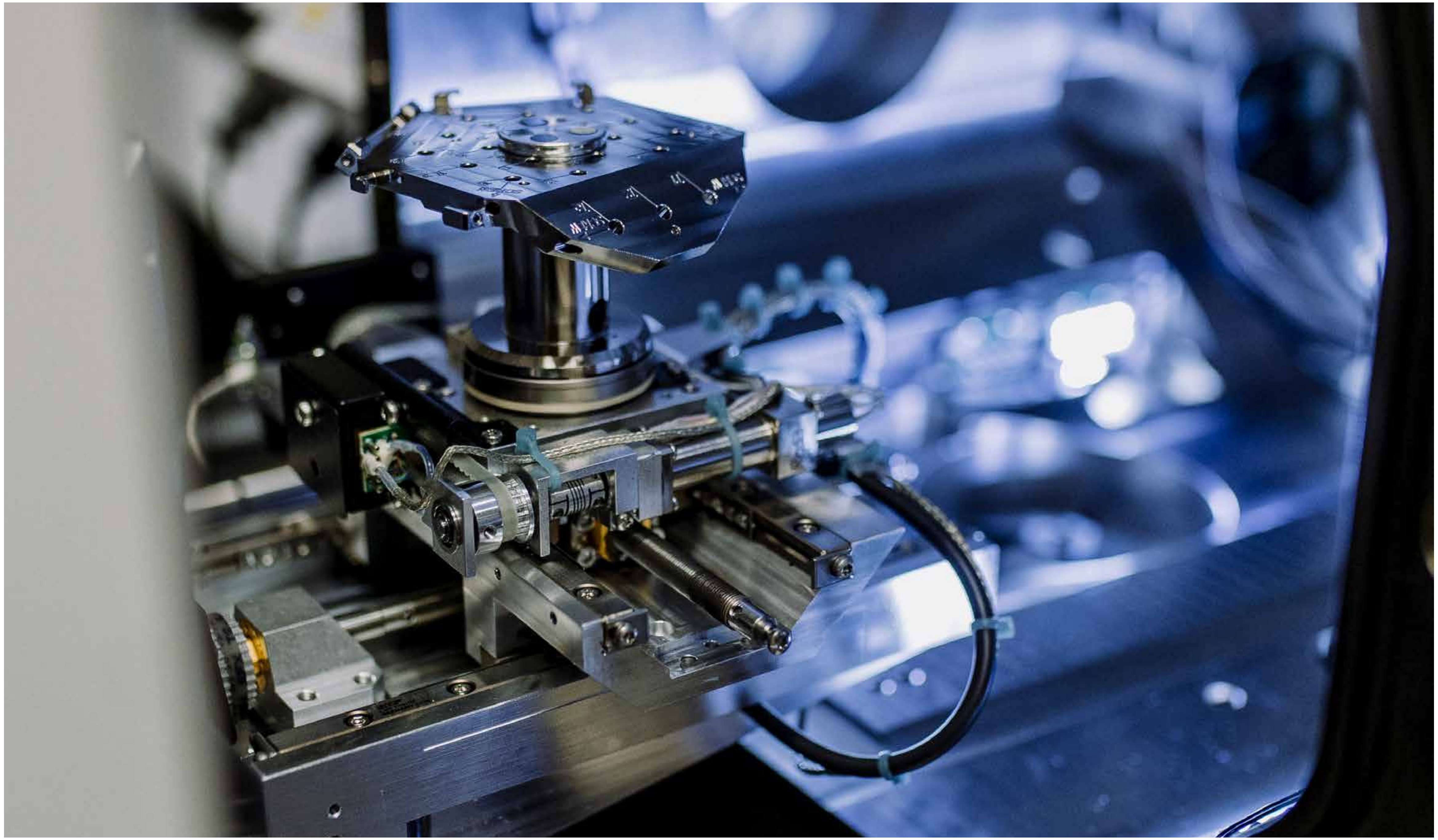
Brainspiration 2022 covered recent progress and future perspectives on brain-inspired concepts and materials for information processing and sensing, including: intelligent matter for information processing and sensing, analog in-memory computing, oscillating neural networks, novel computational devices and architectures in unconventional physical substrates, theoretical concepts of computing in non-digital, physical substrates and neural interfacing.

The meeting was highly interdisciplinary as it aimed at bringing together researchers from physics, chemistry, electrical engineering, materials science, machine learning, computer engineering, nonlinear dynamics etc.

Organisers:
Yoeri van de Burgt
(Eindhoven University of Technology)
Alexander Khajetoorians
(Radboud University Nijmegen)
Beatriz Noheda
(CogniGron - University of Groningen)
Wilfred van der Wiel
(BRAINS – University of Twente)

The second edition of the conference will be in Groningen in 2024.

Industry Relations



Below we alphabetically list the industrial partners who in 2022 worked directly with CogniGron or collaborated via projects involving CogniGron researchers.

aixACCT Systems GmbH
Aachen, Germany

Building Between Bridges
Kortemark, Belgium

CrysTec GmbH
Berlin, Germany

DENSsolutions BV
Delft, the Netherlands

IBM Research Zurich
Zurich, Switzerland

IMEC - Holst
Eindhoven, the Netherlands

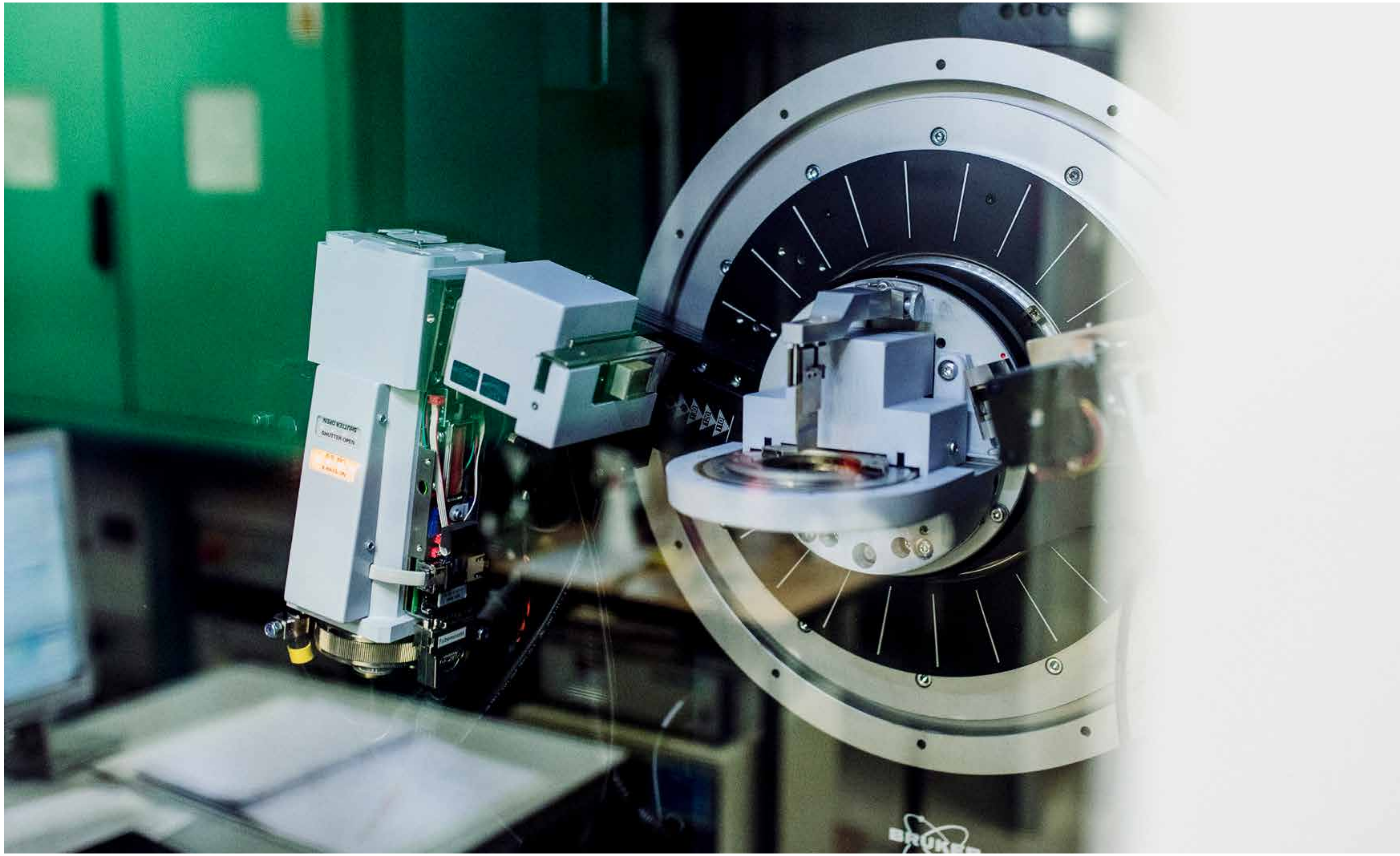
Océ Technologies BV
Venlo, the Netherlands

SmartTip BV
Enschede, the Netherlands

Solmates BV
Enschede, the Netherlands

Twente Solid State Technology BV
Enschede, the Netherlands

Prizes and Awards



Jasper Knoester was awarded a royal decoration

Prof. Jasper Knoester, formed supervisory board member of CogniGron, was awarded a royal decoration on the recommendation of the University Groningen. The decoration was presented to him by Mayor of the Municipality of Groningen, K.F. Schuiling, during his farewell event. Knoester has been appointed as Knight in the Order of the Netherlands Lion.

Jos Roerdink nominated by the UG to be awarded Royal Decoration

Prof. Jos Roerdink nominated by the University of Groningen has received a royal decorations on Tuesday 26 April 2022. Prof. Jos Roerdink has been appointed Knight of the Order of the Netherlands Lion. Jos Roerdink was amongst the first board members of CogniGron and he was key in getting CogniGron to where it stands today.

ERC Advanced Grants for Maria Antonietta Loi and Bart van Wees

The European Research Council has awarded ERC Advanced Grants to two CogniGron members, Prof. Maria Antonietta Loi and Prof. Bart van Wees. They can use this money to set up long-term and ground-breaking research projects. The European Research Council (ERC) awards grants to excellent researchers to stimulate ground-breaking research in Europe. The Advanced Grants are meant for established academics with a track-record of significant research achievements. Advanced Grants may be awarded up to €2,5 million for a period of 5 years.

NIAS fellowship for Prof. Dr. Davide Grossi

Prof. Dr. Davide Grossi from Multi-agent systems has been awarded a fellowship at the Netherlands Institute for Advanced Study. The project title is “Algorithms for Large-Scale Deliberative Democracy” . With the central research question being: If strong modern democracies need to be digital, how can we make sure that the algorithms powering digital democracy applications really adhere to democratic principles? How can we develop digital democracy algorithms that we can trust to be truly democratic?

The NIAS Fellowship allows Davide Grossi to work on his project for a period of 5 months in the academic year 2022/23. He will become part of a carefully selected community of independent thinkers, in a collaborative environment where the space is created to ask new questions beyond disciplinary boundaries. NIAS Fellows are selected through a highly competitive external review process on the basis of the quality of the research proposal.

Publications

Highlighted Publications

After the first years of CogniGron, and with new staff hired and postdoctoral researchers and PhD students starting their projects, an increasing number of scientific results are being published. From the publications submitted in 2021, we highlight the following:

Outstanding Article, Impact Award for Original Research, for the year 2022 by Frontiers in Nanotechnology (Frontiers).

CogniGron is delighted that the article "Anisotropy and Current Control of Magnetization in $SrRuO_3/SrTiO_3$ Heterostructures for Spin-Memristors" by Anouk Goossens, Miina Leiviska and Tamalika Banerjee has been selected for the Outstanding Article, Impact Award for Original Research, for the year 2022 by Frontiers in Nanotechnology (Frontiers).

About the article

Classic computers use binary values (0/1) to perform. By contrast, our brain cells can use more values to operate, making them more energy-efficient than computers. This is why scientists are interested in neuromorphic (brain-like) computing. Physicists from the University of Groningen (the Netherlands) have used a complex oxide to create elements comparable to the neurons and synapses in the brain using spins, a magnetic property of electrons. Their results were published on 18 May in the journal Frontiers in Nanotechnology.

Although computers can do straightforward calculations much faster than humans, our brains outperform silicon machines in tasks like object recognition. Furthermore, our brain uses less energy than computers. Part of this can be explained by the way our brain operates: whereas a computer uses a binary system (with values 0 or 1), brain cells can provide more analogue signals with a range of values.

Thin films

The operation of our brains can be simulated in computers, but the basic architecture still relies on a binary system. That is why scientist look for ways to expand this, creating hardware that is more brain-like, but will also interface with normal computers. 'One idea is to create magnetic bits that can have intermediate states', says Tamalika Banerjee, Professor of Spintronics of Functional Materials at the Zernike Institute for Advanced Materials, University of Groningen. She works on spintronics, which uses a magnetic property of electrons called 'spin' to transport, manipulate and store information.

In this study, PhD student Anouk Goossens, first author of the paper, created thin films of a ferromagnetic metal (strontium-ruthenate oxide, SRO) grown on a substrate of strontium titanate oxide. The resulting thin film contained magnetic domains that were perpendicular to the plane of the film. 'These can be switched more efficiently than in-plane magnetic domains', explains Goossens. By adapting the growth conditions, it is possible to control the crystal orientation in the SRO. Previously, out-of-plane magnetic domains have been made using other techniques, but these typically require complex layer structures.

Magnetic anisotropy

The magnetic domains can be switched using a current through a platinum electrode on top of the SRO. Goossens: 'When the magnetic domains are oriented perfectly perpendicular to the film, this switching is deterministic: the entire domain will switch.' However, when the magnetic domains are slightly tilted, the response is probabilistic: not all the domains are the same, and intermediate values occur when only part of the crystals in the domain have switched.

By choosing variants of the substrate on which the SRO is grown, the scientists can control its magnetic anisotropy. This allows them to produce two different spintronic devices. 'This magnetic anisotropy is exactly what we wanted', says Goossens. 'Probabilistic switching compares to how neurons function, while the deterministic switching is more like a synapse.'

The scientists expect that in the future, brain-like computer hardware can be created by combining these different domains in a spintronic device that can be connected to standard silicon-based circuits. Furthermore, probabilistic switching would also allow for stochastic computing, a promising technology which represents continuous values by streams of random bits. Banerjee: 'We have found a way to control intermediate states, not just for memory but also for computing.'

Neuromorphic Computing and Engineering journal highlights of 2022

The article "Synaptic behaviour in ferroelectric epitaxial rhombohedral $Hf_{0.5}Zr_{0.5}O_2$ thin films" by Yingfen Wei, Gaurav Vats and Beatriz Noheda has been chosen as one of the Neuromorphic Computing and Engineering journal highlights of 2022.

According to Neuromorphic Computing and Engineering the chosen articles provide an example of the high quality, innovative and interesting work that was published in the journal last year. The papers were chosen based on reviewers' reports, and represent our best-regarded articles across a number of topics.

About the article

The discovery of ferroelectricity in HfO_2-based thin films brings tremendous opportunities for emerging ferroelectric memories as well as for synaptic devices. The origin of ferroelectricity in this material is widely attributed to the presence of a polar orthorhombic phase. However, a new ferroelectric rhombohedral phase displaying large polarization with no need of pre-cycling, has more recently been reported in epitaxial $Hf_{0.5}Zr_{0.5}O_2$ (HZO). In this work, the switching mechanism of the rhombohedral phase of HZO films is characterized by a two-stage process. In addition, the synaptic behaviour of this phase is presented, comparing it with previous reports on orthorhombic or non-epitaxial films. Unexpected similarities have been found between these structurally distinct systems. Even though the epitaxial films present a larger coercive field, the ration between the activation field for intrinsic polarization switching and the coercive field (Fa/Ec) has been found to be close to 2, in agreement with that reported for other hafnia samples. This is about 5 times smaller than in most other ferroelectrics, confirming this characteristic as a unique feature of hafnia-based ferroelectrics.

Peer-Reviewed Publications 2022

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Cucchi, M., Abreu, S., Ciccone, G., Brunner, D., & Kleemann, H. (2022). Hands-on reservoir computing: a tutorial for practical implementation. *Neuromorphic Computing and Engineering.*

Koellermeier, J., & Samaey, G. (2022). Spatially Adaptive Projective Integration Schemes For Stiff Hyperbolic Balance Laws With Spectral Gaps. *The SMAI Journal of Computational Mathematics,* 8, 295–325.

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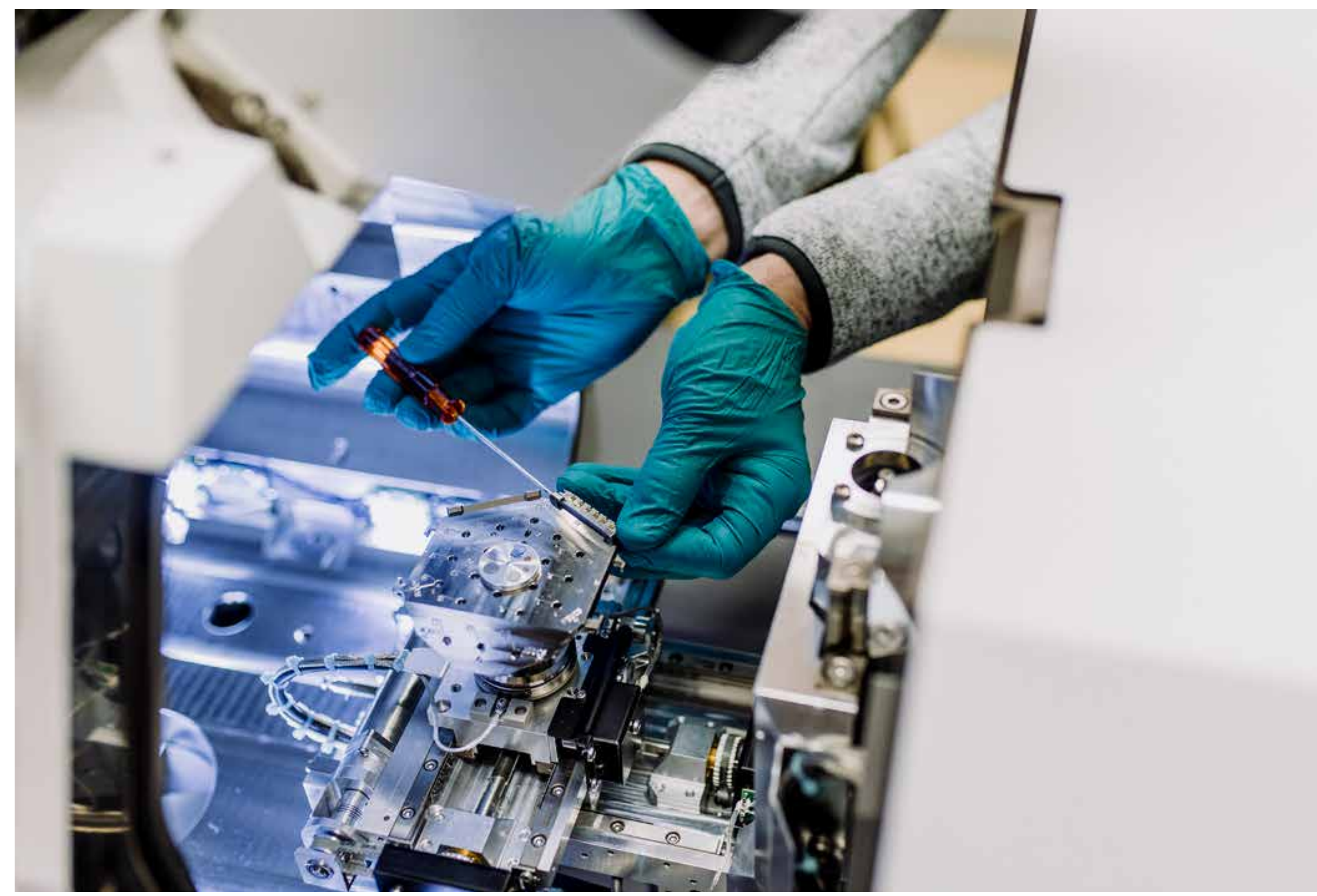


External Funding

We are aware of the unique position that we have and are committed to obtaining the maximum benefits by developing strategic partnerships by means of national or international consortia and taking advantage of the available matching schemes, as long as the partnerships do not compromise our focus. CogniGron is actively participating in or coordinating externally funded projects. Details are provided below:

EU Funding

BeFerroSynaptic – BEOL technology platform based on ferroelectric synaptic devices for advanced neuromorphic processors
This project has received funding from the EU Horizon 2020 research and innovation programme under grant agreement no, 871737
Coordinator: Stefan Slesazeck (NaMLab gGmbH, Germany)
CogniGron participant: Elisabetta Chicca
Amount: € 387.625,00

Insectneuronano – Insect-Brain Inspired Neuromorphic Nanophotonics
This project has received funding from the EU Horizon 2020 European Innovation Council programme under grant agreement no. 101046790
Coordinator: Anders Mikkelsen (Lund University, SE)
CogniGron participant: Elisabetta Chicca
Amount: € 272.990,00

MANIC – Materials for Neuromorphic Circuits
This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 861153
Coordinators: Beatriz Noheda (Groningen) and Bernd Gotsmann (IBM-Research Zurich, Switzerland)
CogniGron participants: Beatriz Noheda, Elisabetta Chicca, Lambert Schomaker, Michael Wilkinson, Jos Roerdink
Amount: € 1.091.836,00

MeM-Scales – Memory technologies with multi-scale time constants for neuromorphic architectures
This project has received funding from the EU Horizon 2020 programme under grant agreement no. 871371
Coordinator: Elisa Vianello (CEA-Leti, Grenoble, France)
CogniGron participant: Herbert Jaeger
Amount: € 304.379,00

MELON – Memristive and multiferroic materials for emergent logic units in nanoelectronics
This project has received funding from the EU Horizon 2020 Research and Innovation Staff Exchange programme under grant agreement no. 872631
Coordinator: Igor Lukyanchuk (University of Picardie Jules Verne, France)
CogniGron participant: Beatriz Noheda
Amount: € 308.200,00

NeuroTech – Neuromorphic Technology
This project has received funding from the EU Horizon 2020 FETPROACT CSA project on Community Building in Neuromorphic Computing Technologies (NCT) under grant agreement no. 824103
Coordinator: Giacomo Indiveri (The University of Zurich and ETH Zurich, Switzerland)
CogniGron participant: Elisabetta Chicca
Amount: € 65.867,30

NouTouch – Understanding neural coding of touch as enabling technology for prosthetics and robotics
This project has received funding from the European Research Council (ERC) under grant agreement no. 813713
Coordinator: Chiara Bartolozzi (Istituto Italiano di Tecnologia, Italy)
CogniGron participant: Elisabetta Chicca
Amount: € 177.079,92

Post-Digital – Post-Digital Computing
This project has received funding from the EU Horizon 2020 programme under Marie Skłodowska-Curie grant agreement no. 860360
Coordinator: Sergei Turitsyn (Aston University, UK)
CogniGron participant: Herbert Jaeger
Amount: € 531.239,76

Respite – Reconfigurable Superconducting And Photonic Technologies Of The Future
This project has received funding from the EU Horizon 2020 Pathfnder programme under grant agreement no. 101098717
Coordinator: Delft University
CogniGron participant: Bart Kooi
Amount: € 395.198,75

National Funding

Nl-ECO
This project has received funding from within the Dutch NWA-ORC scheme under grant agreement no.
Coordinator: Hans Hilgenkamp (University of Twente, NL)
CogniGron participants: Beatriz Noheda, Tamalika Banerjee, Georgi Gaydadjev, Niels Taatgen and Elisabetta Chicca.
Amount: TBA

Materials for neuromorphic devices
This project has received funding from an NWO Visitor's Travel Grant under grant agreement no. 9047
Applicant: Beatriz Noheda
Visitor: Prof. Diego Rubi (University of Buenos Aires, Argentina)
Amount: € 7.500,00

Other International Funding

MemTDE – Memristive Time Difference Encoder
This project has received funding from the German Science Foundation (DFG) under individual research grant agreement no. 441959088
Applicant: Elisabetta Chicca
CogniGron participant: Elisabetta Chicca
Amount: € 278.750,00

MAKI - Multi-Mechanisms Adaptation
This project has received funding from the German Science Foundation (DFG) via the Collaborative Research Centre 1053
Applicant: Boris Koldehofe
CogniGron participant: Boris Koldehofe
Amount: funding goes via University of Darmstadt

Groningen contributes to major National research initiative into energy-efficient information technology: NL-ECO

The Dutch science funding agency NWO recently awarded a large research project into new concepts for energy-efficient information technology of no less than ten million euros. The widespread use of digital equipment and technologies, such as computers, the internet and data centers often make our lives a lot more efficient and offers opportunities in for example medical applications. However, these technologies consume lots of energy. Moreover, the amount of digital information we process and store and the associated energy costs is growing exponentially. In order to reduce this rapidly increasing energy consumption, the NL-ECO research project aims to develop new materials, technologies and scientific insights for energy-efficient information technology. A consortium of 33 organizations will conduct fundamental research into the digital technologies of the future. The research project is getting the funding as part of the research programme 'Research along Routes by Consortia' of the Dutch National Research Agenda (NWA-ORC).

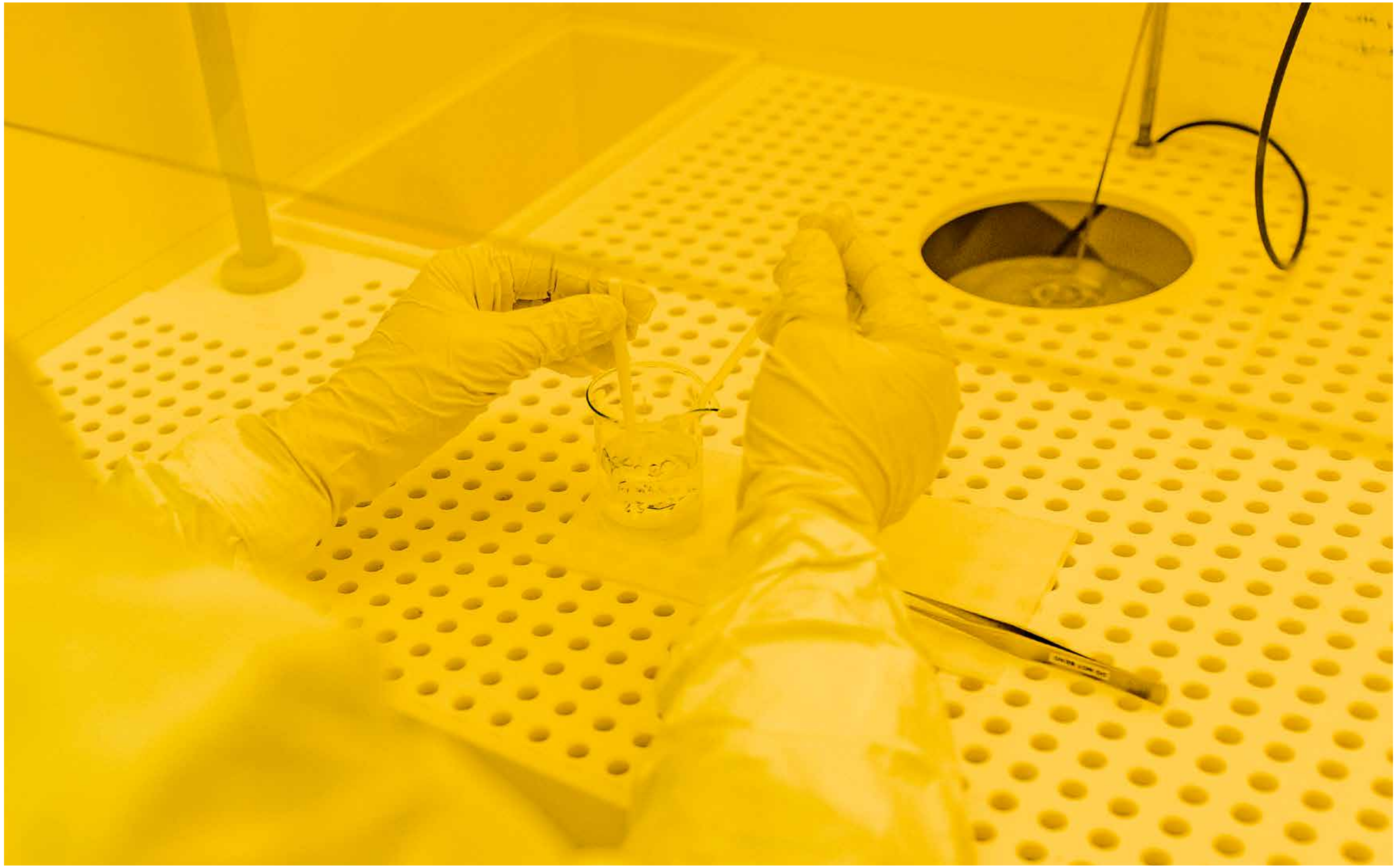
Groningen

This broad consortium consists of 33 organizations covering academia, social partners and industry, coordinated by Hans Hilgenkamp from the Technical University Twente. The CogniGron research center, Zernike Institute for Advanced Materials and Bernoulli Institute for Mathematics, Computing Science and Artificial Intelligence are involved and represent the University of Groningen. 3 PhDs are funded from NL-ECO and CogniGron matches these with its own PhD students. The municipality of Westerkwartier and Science Linx are participating as the societal partners from the North of The Netherlands. Together with these northern partners, NL-ECO wants to involve society in the further development of these sustainable information technologies. For example, so-called "demonstrators" will be developed, whereby citizens can become part of this new technolgy. The "living lab" in Zuidhorn (municipality of Westerkwartier), which was developed in collaboration with Science Linx, has been designated as the location for this. CogniGron already has a test set-up here in which energy is generated by means of the pressure exerted by pedestrians on a pavement tile. The data generated in this way will be supplied to a "neuromorphic" computer

Brain as inspiration

Together with CogniGron, NL-ECO will look at the brain for inspiration for the development of new technologies, among other things. This is actually the most energy efficient computer we know of. Beatriz Noheda, director of Cognigron: "This research project fits in perfectly with CogniGron's ambitions and goals. Here we are already working hard to develop a blueprint for the computer of the future. A computer that works completely differently from our current computers. CogniGron conducts fundamental research into self-learning materials and systems for a cognitive computer – computing that has the ability to learn and perform complex tasks in such as efficient way that we will not need supercomputers and data centers for many of tasks: information will be processed at the device itself. We are proud to be able to contribute to the NL-ECO research project and are looking forward to the collaboration with Hans Hilgenkamp and all other partners herein."

Contact Information



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