

Faculty of Science and Engineering

Profile report: Cognitive Devices (Cognitieve devices)

- Discipline: Device Physics/ Nanoelectronics
- Level: Tenure-Track Assistant/Associate/ Full professor
- Fte: Full time (1,0)

1. Scientific discipline

Nanoelectronics comprises the understanding of electronic processes and development of electronic materials and devices at the nanoscale. The focus is on devices that show adaptable and multi-valued electronic, magnetic, optical or mechanical properties, as key elements for brain-inspired devices.

2. Vacancy

This position is opened by the Board of the Faculty (PT/gl/18/00140) as part of the Center “CogniGron - Groningen Cognitive Systems and Materials”, which aims to develop systems and materials for cognitive computing. The position will be embedded in the Zernike Institute for Advanced Materials, and falls within the framework of ‘Career Paths in Science 3’ (‘Bèta’s in Banen 3’). Please see link for [criteria and conditions](#).

3. Selection committee (BAC)

Prof. dr. ir. C.H. van der Wal	Scientific director of the Zernike Institute for Advanced Materials and professor Physics of Quantum Devices (Chair);
Prof. dr. B. Noheda	Director Groningen Cognitive Systems and Materials and professor Nanostructures of Functional Oxides
Prof. dr. M.J.E.C. van der Maarel	Professor Aquatic Biotechnology and Bioprocess Engineering and director Graduate School of Science;
Prof. dr. M.A. Loi	Professor Photophysics and Photoelectronics
Prof. dr. J. Ye	Professor Device Physics of Complex Materials
Prof. dr. J.P. Locquet	External member, professor Semiconductor Devices, KU Leuven (Belgium)
Floris Westerman	Student member

Advisors:

Prof. dr. J.B.T.M. Roerdink	Scientific director Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, and professor Scientific Visualization and Computer Graphics
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Dr. J.H.M. van der Velde

Scientific Coordinator Groningen Cognitive
Systems and Materials and secretary of the
selection committee

HR advisor:

Ms. A. van der Woude

Besides the members of the committee also Board of Zernike Institute and Board of the Center Groningen Cognitive Systems and Materials may be consulted regarding the eligibility of the candidate.

4. Research area

The general profile of the position is experimental research on *brain-inspired devices* and will involve the design, fabrication, characterization and testing of new devices for cognitive computers. The field of cognitive materials and devices is believed to propel data processing forward with the development of more efficient, smaller and faster systems, taking advantage of new materials and devices that emulate synaptic behaviour (adaptability and plasticity) and neural behaviour (memory/multi-valued responses). This can be achieved by a way of computing that, inspired by the working mechanism of the brain, combines parallel processing, analogue signals and co-localization of processing and memory. These characteristics endow the brain with the capability to deal with large amounts of heterogeneous and complex (sensory) data, filtering, classifying and prioritizing in a very efficient manner. Thereby, this research area will respond to the need for devices in information processing that work *via* very different concepts than the current CMOS technology does.

It is envisioned that this position will mostly consist of fundamental science, discovering and developing devices with learning capabilities that combine memory and adaptability to be used as key elements in cognitive computers.

The new staff member will strongly collaborate with other disciplines and expertise. Most important will be the collaborations with the materials scientists and with a circuit designer with knowledge in the circuit integration of cognitive bio-inspired devices. This provides the necessary knowledge to integrate materials in working circuits that can be tested for cognitive applications, such as voice or text recognition and data classification. Additional collaborations within FSE in mathematics, computer science and artificial intelligence (in particular image analysis, dynamical networks, systems and control theory and stochastic methods) are needed. These collaborations will allow for the processing of large data sets and complex images acquired from new materials and devices. Additionally, it is useful in the development and analysis of the working networks and stochastic data. To achieve optimal performance and learn how to modify the cognitive devices in working integrated circuits, feedback is required from experts in cognitive systems, neuromorphic computing and algorithm development.

5. Embedding: institute (and base unit)

The group Cognitive Devices will be established within the Zernike Institute for Advanced Materials and play a crucial role within the Center “CogniGron - Groningen Cognitive Systems and Materials”. Together with the Neuromorphic Circuit Design Engineer position, it will be instrumental in bridging the materials expertise with the artificial intelligence and computer science expertise, already existing in the Faculty of Sciences and Engineering (FSE). If a full professor is selected and appointed, the candidate may also be offered to establish and lead a new research unit on Cognitive Devices.

The CogniGron - Groningen Cognitive Systems and Materials Center is a joint venture between FSE-institutes Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, and the Zernike Institute for Advanced Materials. It comprises researchers from materials science, physics, chemistry, mathematics, computer science and artificial intelligence. The center provides structure, coherence, and visibility for a joint research program in the direction of cognitive systems and materials. The main goal of the Groningen Cognitive Systems and Materials Center is to create self-learning materials that will perform the tasks that are now assigned to thousands of transistors and complex algorithms in a more efficient and straightforward manner, hence, forming the basis for a new generation of computer platforms for cognitive applications, such as pattern recognition and analysis of complex data.

The Zernike Institute for Advanced Materials is one of the leading institutes in the field of materials science. Its goal is to design, build and connect nanostructured and (bio)functional materials to achieve unprecedented functionality.

6. Local and (inter)national position

The Brain-inspired devices group will occupy a unique position both at the national and international level, being part of the research center “CogniGron - Groningen Cognitive Systems and Materials”.

In the Netherlands few efforts in this direction are currently being set up. A relevant research initiative is the implementation of organic transistors for neuromorphic applications by dr. Y. van der Burgt (TU Eindhoven) or Prof. dr. ir. W.G. van der Wiel (U Twente). Additionally, there is the Bits&Brains consortium in which the FSE (U. Groningen) participates together with the universities of Nijmegen, Twente and Utrecht.

Internationally, industrial research organizations, such as IBM, HP and IMEC, are moving strongly into this direction, by investing in so-called neuromorphic computers in parallel to their efforts on quantum computers. There are a few comparable academic research groups, though with a different focus on the topic. The group of Julie Grollier at CNRS/Thales (Paris) is focussing on spintronic-based bio-inspired devices. The groups of Rainer Waser (FZ-Jülich), Siegfried Karg (IBM-Zurich), Heike Riel (IBM-Zurich) and Jean-Pierre Locquet (KU Leuven) are studying two-terminal memristive devices. Agnes Barthelemy (CNRS-Thales), Manuel Bibes

(CNRS-Thales) and Jean Fompeyrine (IBM-Zurich) are focussing rather on ferroelectric memristors. Additionally, important efforts are taking place in China and Japan (AIST being a strong contender) as well as the US (*e.g.* Ivan Schuller is developing a large initiative on memristors for neuromorphic computers in the US).

7. Expected contributions to research

The candidate is expected to initiate and develop an internationally leading research programme in the field of brain-inspired devices. The research should have a visibility at the international level and lead to publications in top journals. Further, it is expected that the new professor will take a leading role in the field of brain-inspired devices within the Netherlands. The research programme is also expected to initialize collaborations and cross-fertilize with the existing research both within the Groningen Cognitive Systems and Materials center and the Zernike Institute and should thus strengthening the international reputation of the research center and institute. Obtaining substantial external funding for PhD projects is crucial. Supervision of PhD students is an important part of the research activities.

8. Expected contributions to teaching

The candidate is expected to contribute to the teaching programmes in the bachelor and master degree programs within the Undergraduate and Graduate Schools of Science and Engineering. She/he is expected to participate in the teaching programme of specialized courses in relation to brain-inspired devices, adaptable electronics and other related topics. These topics are currently little represented in the faculty and can be linked to teaching in electronics, nanoelectronics, spintronics, 2D materials, memristive materials, *etc.* Furthermore, the candidate will be involved in supervising bachelor, master and PhD students.

Upon appointment, depending on experience and formal qualifications to date, the candidate may be required to enter a nationally standardized tertiary teaching skills certification trajectory (BKO or Basis Kwalificatie Onderwijs), successful completion of which is a condition for extensions and tenure.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of the FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees in the area of teaching, research, and management. The candidate will participate in relevant national and international organizations.