

Faculty of Science and Engineering

Profile report: Nano electronics and spintronics of 2D materials and devices
(nano-elektronica en spintronica van 2D materialen en devices)

- Discipline: Physics/ Applied Physics
- Level: Tenure track assistant/associate professor
- Fte: Full time (1,0)

1. Scientific discipline

The position aims at studying (opto) electronics, (opto) spintronics, magnetism and/or spin caloritronics in 2D materials, as well as in their heterostructures and devices thereof. The study of hybrid heterostructures of (anti) ferromagnetic insulating materials, where the spin transport is carried or controlled by magnons and/or skyrmions is also included. The focus of the position is on the study of interconversion between charge, spins, heat and light in these materials and devices, and exploring the resulting new functionalities. The technological expertise required includes (a combination of) growth and preparation of the materials, device fabrication and dedicated measurements either under ambient conditions, and/or at low (cryogenic) temperatures and/or high magnetic fields.

2. Vacancy

This position is opened by the Board of the Faculty (PT/gl/18/00334) and will be embedded in the Physics of Nanodevices group/base unit of the Zernike Institute for Advanced Materials. The position 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. C.H. van der Wal, scientific director of the Zernike Institute for Advanced Materials and professor Physics of Quantum Devices (Chair)

Prof. dr. B.J. van Wees, professor and chair Physics of Nanodevices

Prof. dr. ir. P.R. Onck, Deputy director Physics/Applied Physics Masters education and professor Micromechanics of Cellular and Active Materials

Prof. dr. T. Banerjee, professor Spintronics of Functional Materials

Prof. dr. M. Stöhr, professor Surface Science

Prof. dr. J. Ye, professor Device Physics of Complex Materials

Ceri Richards (Master student Physics)

Prof. dr. W.G. van der Wiel, External member, professor and chair of Nanoelectronics, University of Twente

Dr. J.P. Birkner (advisor, Research Manager Zernike Institute)

Ms. A. van der Woude (advisor, Human Resources)

4. Research area

Since the advent of graphene in the last decade many 2D materials have emerged with new and improved functionalities. In particular heterostructures of these materials offer

unprecedented possibilities for exploring new physical phenomena, as well as new functionalities for future (nanoelectronics) applications. Research into these materials has expanded over the recent years, and now includes new types of superconductivity (Ising and topological), magnetism, (opto)-electronics, spintronics and more. Currently the best quality materials are obtained by mechanical exfoliation from crystals, which have either been formed in nature (such as graphite) or have been grown by dedicated processes (such as done by several companies, including HQ Graphene at the Zernike Campus Groningen). However, there is a strong drive towards the large-scale preparation (e.g. with CVD) of these materials. Key issues are also the controlled preparation of high quality devices based on these materials and heterostructures.

A related field is spintronics of magnonic and skyrmionic systems. Here spin waves (magnons) and topological spin excitations (such as skyrmions) are used to carry or control (spin) information. Research in this area includes spin caloritronics, the study of the coupling between charge, heat and spin in various systems, in particular in insulating ferro (or ferri) magnetic materials. Currently this field is moving towards the controlled generation, transport and detection of spin information in dedicated devices consisting of these materials or in heterostructures with other insulating, semiconducting or metallic materials.

The expertise required for the above research includes material growth and preparation, device fabrication and dedicated measurement, either under ambient conditions, or at low temperatures and/or high magnetic fields.

5. Embedding: institute (and base unit)

The position is newly created within the base unit Physics of Nanodevices at the Zernike Institute for Advanced Materials.

The mission of the Zernike Institute of Advanced Materials (<https://www.rug.nl/research/zernike/>) lies in focused, curiosity-driven, symbiotic studies of functional materials involving researchers from physics, chemistry and biology. Our main driving force is the desire to understand how things work at the microscopic level, also known as the atomic and molecular scale. This is the realm of nanoscience and nanotechnology. In this field, the Zernike Institute for Advanced Materials covers the whole chain from synthesizing materials, building devices, characterizing materials and devices, and investigating the theoretical foundation of their properties. The institute performs interdisciplinary research with the Stratingh Institute for Chemistry and the Groningen Biomolecular Sciences and Biotechnology Institute.

The base unit Physics of Nanodevices (<https://www.rug.nl/research/zernike/physics-of-nanodevices/>) also includes the groups Spintronics of Functional Materials (Prof. T. Banerjee) and Physics of Quantum Devices (Prof. C.H. van der Wal). It has currently about 30 employees. Subjects of study are: (i) spin and charge transport in graphene, 2D materials and their heterostructures and devices, (ii) quantum optics, opto-electronics and spintronics in organic, inorganic semiconductors and oxide materials, (iii) spin caloritronics, (iv) (magnon) spintronics in magnetic nanodevices and insulating ferromagnets, and (v) charge and spin dynamics in semiconductor and organic systems. Several facilities are available for the research, including the nanofabrication facilities of Nanolab NL (<http://www.nanolabnl.nl/>)

6. Local and (inter)national position

The Physics of Nanodevices group collaborates with several groups in the Zernike Institute on the study of magnetism, spintronics, superconductivity and optoelectronics of 2D materials and oxide materials. Groups include the Photophysics and Optoelectronics group of Prof. Loi on (opto)electronics of carbon based materials, the group of Prof. Banerjee on spintronics of oxide based systems, the Device Physics of Complex Materials group of Prof. Ye on study of properties (e.g. induced superconductivity) of 2D materials, the groups of Prof. Stöhr and Rudolf on the (surface) science of (functionalized) graphene systems, and the groups of Prof. Noheda on preparation of skyrmion materials. There are also strong ties with the group Theory of Condensed Matter, especially with Prof. Mostovoy (skyrmions/skyrmionics) and Prof. Bauer (spintronics/spin-caloritronics).

On the national level collaborations are present with other experimental and theoretical groups in the Netherlands e.g. through national programs on (magnon) spintronics and skyrmion physics. These include Prof. Duine at Utrecht University, Prof. Palstra at Twente University, and Prof. Pappas at Technical University Delft. The group also interacts with other spintronics groups in the Netherlands, including Prof. Swagten, Prof. Koopmans and Prof. Flipse (TU Eindhoven) and Prof. Rasing (Radboud University).

International collaborations exist with various experimental and theoretical groups from the EU Graphene Flagship on electronics and spintronics of graphene and other 2D Van der Waals materials. This research aims to push the science and technology of 2D materials and devices towards future applications. Current subjects of studies and collaborations are spin transport and spin manipulation in graphene-based 2D materials and devices based on large area materials growth.

In the area of spin-caloritronics international collaborations exist e.g. with the groups of Prof. E. Saitoh (Tohoku University), prof G. Reiss and dr. T. Kuschel (Bielefeld University) on magnon transport and dynamics in various material systems.

7. Expected contributions to research

The candidate is expected to initiate and develop a research program in one (or more) topics mentioned above. The research should have a visibility on the national and worldwide level and lead to publications in top journals. The research is expected to cross-fertilize the existing research within the institute (e.g. Prof. B.J. Van Wees, Prof. T. Banerjee, Prof. C.H. van der Wal, Prof. J. Ye, Prof. P. Rudolf, Prof. M. Stöhr, and Prof. M.A. Loi) and should lead to a strengthening of the international reputation of the group and the institute. Obtaining substantial external funding is crucial. Supervision of PhD students is an important part of the research activities. The research is expected to strengthen the existing efforts within the Zernike Institute for Advanced Materials in the field of functional materials and devices and to take an international leadership role.

8. Expected contributions to teaching

The candidate is expected to contribute to the teaching in the bachelor and master degree programs within the Undergraduate and Graduate Schools of Science and Engineering, as well as to the Top Master program Nanoscience, organized by the Zernike Institute. She/he is expected to participate in the teaching program of specialized courses in relation to nano

electronics and spintronics of 2D materials and other related topics. 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, the University Teaching Qualification (UTQ) [in Dutch Basis Kwalificatie Onderwijs (BKO)], successful completion of which is a condition for promotion to a higher rank.

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 fields of teaching, research and management. The candidate will participate in relevant national and international organizations.