

Faculty of Science and Engineering

Profile report: *Quantum materials (Quantum materialen)*

- Discipline: *Physics and Applied Physics, Materials Chemistry*
- Level: *Tenure-track assistant professor*
- Fte: *Full time (1,0)*

1. Scientific discipline

Quantum materials are materials that exhibit uncommon states of matter that present quantum properties and emergent phenomena on a macroscopic scale. Some examples are materials that show new forms of magnetism or superconductivity. Their characteristics can be assessed with highly developed solid state physics tools, which give information about the bulk and surface structure, morphology, vibrational and electronic properties, as well as emergent and topological phenomena. Advancing the forefront of this fields requires close collaboration between material synthesis, state-of-the-art characterization and theory. Currently, innovations in the area of thin films, 2D materials and related layered structures are a strong driver for this discipline.

2. Vacancy

This position is opened by the Board of the Faculty (ref. PT/gl/22/00271) and will be embedded in the Zernike Institute for Advanced Materials, research unit Surfaces and Thin Films. The position falls within the framework of 'Career Paths in Science 4' ('Bèta's in Banen 4'). 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 in Physics of Quantum Devices (Chair)

Prof.dr.ir. B.J. Kooi, education director of the Zernike Institute for Advanced Materials and professor in Nanostructured Materials and Interfaces

Prof.dr. B. Noheda, director CogniGron, professor in Nanostructures of Functional Oxides,

Prof.dr. M. Tromp, professor in Materials Chemistry

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

external member

Rixt Bosma, Student member (MSc Nanoscience)

Dr. A. Grubisic-Cabo (advisor, assistant professor in the unit Surfaces and Thin Films)

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

Ms. M. Laning (advisor, Human Resources)

4. Research area

The research area quantum materials is an interdisciplinary effort with close collaboration between theory, experimental physics and chemistry, and technological

innovations. Currently, controlled modifications of the structure of quantum materials, and in particular Van der Waals materials and their heterostructures, are gaining a lot of interest in the community. Some of the relevant examples are use of proximity effects to change and enrich the properties of the material of interest, and in-operando studies, where, for example, samples are electrically biased or mechanically strained. To understand the properties and modifications of quantum materials it is essential to control and study them at the atomic scale, and to improve insight in the relation between the emergent states, the structure and doping of the material, as well as the role of defects. Examples of expertise and techniques that are needed are -in addition to material synthesis- various scanning-probe-based techniques (different types of STM, AFM, SNOM), XPS, and various X-ray and electron (and neutron) diffraction techniques (possibly in part at large-scale facilities). This experimental position will focus on advancing these techniques, while applying them to explore quantum materials, such as complex oxides, and van der Waals materials and their heterostructures. Synergy is expected with experts on synthesis and modelling of quantum materials and heterostructures as well as with colleagues specialized in optical and electronic transport properties of nanostructures and (opto-)electronic or spintronic devices.

5. Embedding: institute (and base unit)

The position will be embedded within the research unit Surfaces and Thin Films at the Zernike Institute for Advanced Materials and strongly links to various education and research programmes of the School of Science and Engineering, especially courses with Physics and Applied Physics content.

The mission of the Zernike Institute for Advanced Materials lies in focused, curiosity-driven, symbiotic studies of functional materials involving researchers from physics, chemistry and bio-nanosciences. The Zernike Institute's main driving force is the desire to understand how things work at the microscopic level, i.e. 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 other Institutes of the Faculty of Science and Engineering and with the UMCG.

The research unit Surfaces and Thin Films is led by Prof. Rudolf. The group has a research program in the field of Surface and Interface Physics with particular emphasis on the preparation and analysis of crystalline organic thin films, 2D solids, functional molecules as well as molecular motors and switches on surfaces, and nanocomposites, while training

young researchers at the master, PhD and postdoctoral level in state-of-the-art surface analysis techniques and research in the field of Surface and Interface Physics.

The research unit consists of two staff members, Prof.dr. Petra Rudolf and Dr. Antonija Grubisic-Cabo, 1 honorary professor, 3 Postdoctoral fellows, 13 PhD students, and technical and secretarial support.

6. Local and (inter)national position

The position is created to strengthen the Faculty's profile in the area where physics and chemistry collaborate on materials science. It will focus on Quantum Materials. The focus of the position may open further collaborative avenues within the Zernike Institute and other institutes of the Faculty of Science and Engineering. Locally, it links well to e.g. the research of the groups Physics of Nanodevices, Nanostructures of Functional Oxides, Device Physics of Complex Materials, Theory of Condensed Matter, and Materials Chemistry.

Note that, while collaboration is encouraged, too much overlap with existing research activities at the Zernike Institute that mainly electron microscopy (SEM, TEM, STEM), angle-resolved photoemission spectroscopy techniques and molecular ultrafast spectroscopy is considered undesirable.

In the Netherlands complementary fundamental research on quantum materials is carried out in Amsterdam (Golden), Utrecht (Vanmaekelbergh, Morais Smith), Nijmegen (Khajetoorians, Kimel, Katsnelson), Eindhoven (Creatore, González Curto), Delft (Kuipers, Otte), and Twente (Brinkman, Hilgenkamp, Rijnders, Zandvliet).

Internationally, Thales (France), Geneva (Switzerland), [Max Planck Graduate Center for Quantum Materials](#) (Germany, cluster of several MPI's), many other German Universities, Oxford University (UK), Copenhagen University (Denmark), giant [national programs, centres of the national science foundation](#) and top Universities in the USA (e.g. [Harvard](#)).

7. Expected contributions to research

The candidate is expected to initiate and develop their own research program in the field of Quantum Materials. They are expected to interact closely with other research groups of the institute. The research should have a visibility both at the national and the international level and lead to scientific publications. The research is expected to cross-fertilize the existing research within the Zernike Institute, and other institutes of the Faculty of Science and Engineering.

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 in the field of Quantum Materials and to take an international leadership role.

8. Expected contributions to teaching

The candidate is expected to teach at the bachelor and master level, in particular in the areas of physics, applied physics and/or chemical physics, and to contribute to the Topmaster program in Nanoscience organized by the Zernike Institute. They are expected to participate in the teaching program of specialized courses in relation to Quantum Materials and other related topics. Furthermore, the candidate will be involved in supervising bachelor, master and PhD students.

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.