

Faculty of Mathematics and Natural Sciences

Profile report: Smart micro energy systems / Slimme micro energiesystemen

- Discipline: *Micro electro-mechanical systems; micro electronics; mechatronics; systems engineering;*
- Level: tenure-track Assistant professor
- Fte: Full time (1,0)

1. Scientific discipline

Micro electro-mechanical systems and microelectronics are disciplines that study the design and properties of integrated electrical and mechanical devices made out of micrometer-size components. It is a multidisciplinary engineering discipline with a strong interaction between precision engineering, microelectronics, software engineering, mechatronics and systems engineering.

2. Vacancy

This position is opened by the Board of the Faculty (ref. number EMK/gl/16/00262) and will be embedded in the Engineering and Technology institute Groningen (ENTEg), basic unit Discrete Technology and Production Automation. 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. ir. J.M.A. Scherpen (Chair, Director of ENTEg)

Prof. dr. B. Jayawardhana (Discrete Technology and Production Automation, ENTEg)

Prof. dr. B. Noheda (Nanostructures of Functional Oxides, ZIAM)

Prof. dr. Y. Pei (Advanced Production Engineering, ENTEg)

Prof. dr. P. Rudolf (Director of the Graduate School of Science)

Prof. dr. ir. A.J. H. M. Rijnders (Inorganic Materials Science Group, UTwente, external expert)

Mr. Tim Kousemaker (student member)

Advisors:

Prof. dr. ir. J. Post (Advanced Production Engineering, ENTEg)

Mr. H.Y. Haagma (HR Advisor)

4. Research area

The research field of micro electro-mechanical systems (MEMS) has played an important role in the miniaturization of electro-mechanical systems and has become ubiquitous in smartphones and other smart devices. However, many of these devices are still powered by a battery which cannot autonomously recharge itself, *i.e.* the battery has to be replaced, or recharged by connecting it to an external power source. This limits the design space for novel MEMS devices, for example, for smart biomedical implants and smart sensor systems in remote and difficult areas. Therefore, it is important to study the design of MEMS devices

that are able to harvest energy by themselves so the smart device can operate autonomously, and is not dependent on an external power source. The envisioned research on smart micro-energy systems focuses on research activities that are related to the miniaturization of energy harvesting systems using piezoelectricity. It includes the embedding of such systems in a device, thus taking a mechatronics design perspective, and deals with research activities on micro transduction technology, on rectification systems (which is the processing of the AC outputs of energy harvesting systems into regulated low voltage DC, suitable for powering an ultra-low power sensor node), as well as, on micro power management systems.

5. Embedding: institute (and base unit)

The research conducted at the Engineering and Technology institute Groningen (ENTEg) is multidisciplinary and covers a broad area of mechanical engineering, electrical engineering, chemical engineering, biotechnology and information technology. ENTEg is positioned within the Faculty of Mathematics and Natural Sciences and is currently composed of the following research units:

- Advanced Production Engineering (prof. dr. Y. Pei)
- Aquatic Biotechnology and Bioproduct Technology (prof. dr. M.J.E.C. van der Maarel)
- Chemical Technology (prof. dr. H.J. Heeres)
- Discrete Technology and Production Automation (prof. dr. Ir. J.M.A. Scherpen)
- Products and Processes for Biotechnology (prof. dr. G.J.W. Euverink)
- Product Technology (prof. dr. F. Picchioni)
- Smart Manufacturing Systems (prof. dr. C. De Persis)

Depending on the research line of the candidate, the research performed will be embedded in the research unit Discrete Technology and Production Automation (DTPA) or Advanced Production Engineering (APE). Research within DTPA is focused on the dynamical modeling, analysis and systems engineering of complex electro-mechanical systems. The application areas include smart energy systems, mechatronic systems, robotic systems, as well as, multi-agent autonomous systems. The APE research unit, on the other hand, focuses on mechanical precision engineering and on material science. More specifically, research activities within this unit covers the modeling and analysis of interface interactions in micro, meso and macro scale, on the engineering and production process of devices with novel materials, and on design and characterization of micro mechanical systems. The units DTPA and APE have a number of on-going research collaborations and the candidate will strengthen the research interaction between these two units.

Furthermore, there are possibilities for collaboration on the material side with the research unit Nanostructures of Functional Oxides from the Zernike Institute for Advanced Materials (ZIAM) chaired by prof. dr. B. Noheda.

6. Local and (inter)national position

In the Netherlands, similar research activities are conducted in the Inorganic Material Science group and Mesa+ Institute at the University of Twente and in the department of Precision and Microsystems Engineering at Delft University of Technology. In general, the focus at University of Twente and at Delft University of Technology is on the transduction technology while our institute/research within the scope of the new position will focus more on the use of novel materials and on novel rectification & power management systems. It is foreseen that the new position will have unique possibilities of local synergies with the mechatronics group of prof. dr. Bayu Jayawardhana and the nanostructures of functional oxides group of prof. dr. Beatriz Noheda.

Internationally, there are numerous research activities on micro energy harvesting systems, such as prof. dr. Zhong Lin Wang's group at Georgia Institute of Technology and prof. dr. Paul Mitcheson's group at Imperial College London. The candidate is strongly encouraged to set up international collaborations, for example in the area of rectification and power management systems or in the area of material science.

7. Expected contributions to research

The candidate is expected to set up his/her own research group in the field of smart micro-energy systems. This includes obtaining research grants and supervision of PhD-students. In particular, he/she

- will design, develop and characterize new transduction technology based on novel piezoelectric material;
- will design and develop active rectifying systems that transfer real and reactive power between a transducer and a storage element (capacitor or battery);
- will design and develop optimal power management systems that can optimally balance the power generation, storage and energy transfer;
- will design and develop integrated self-powered sensor systems for novel application areas.

8. Expected contributions to teaching

The candidate will contribute 30% of her/his time to the teaching programs at the University of Groningen, in particular the Bachelor and Master programmes in Industrial Engineering and Management¹, Applied Physics², the bachelor programme in Life Science and Technology with a major in Biomedical

¹ The detail of BSc IEM programme can be found in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=3753> and that of MSc IEM programme can be read in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=3754>

² The detail of BSc Applied Physics programme can be found in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=4967> and that of MSc Applied Physics programme can be read in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=3377>

Technology³, the Master programme in Biomedical Engineering⁴ and new Master's degree programmes in Engineering that are under development. It is also expected that the candidate will contribute to the specialization of Advanced Production Engineering and/or of Smart Systems in Control and Automation within the Master's degree programme in Industrial Engineering and Management.

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 FMNS, 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.

³ The detail of BSc LS&T programme with major on Biomedical Technology can be found in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=3725>

⁴ The detail of MSc BME programme can be found in <http://www.rug.nl/ocasys/fwn/vak/showpos?opleiding=3219>