UNIVERSITY OF TWENTE.

Ph.D. position on investigation of epitaxial thin film microbatteries

University of Twente, MESA+ Institute for Nanotechnology, Netherlands
Supervisor : Prof. Mark Huijben

Research description

With the fierce development of advanced microelectronics for a wide range of wireless applications (e.g. 5G communication, IoT sensors/actuators, environmental/security monitoring, implantable medical systems and wearable electronics) miniaturized energy storage devices have become crucial to enable their autonomous operation. Although micro-supercapacitors possess high power densities and long cycle life, only microbatteries can deliver energy densities on the order of magnitude required for these wireless, autonomous microelectronic devices. Although encouraging achievements have been realized in the past decade by novel architectures and fabrication methods, still considerable challenges exist to obtain reliable, high performance microbatteries for practical miniaturized applications.

Within the VICI research program novel epitaxial microbattery devices will be developed and investigated by state-of-the-art (operando) techniques to gain vital comprehensive understanding on how crucial processes proceed (mechanism and kinetics) and how these depend on interface properties (e.g. chemistry, crystal orientation, surface termination). Driven by the achieved fundamental understanding advanced integration with the silicon platform will be explored, which is imperative to enable the application in actual modern microelectronic devices.

Research plan

Epitaxial engineering has proven to be a successful tool for achieving advanced functional properties in complex oxide thin films, which cannot be obtained in single crystals or polycrystalline samples. Pulsed laser deposition (PLD) has emerged as a versatile technique for the deposition of high-quality, epitaxial thin films from a wide variety of complex oxide materials, including superconductors, metals, ferroelectrics, ferromagnets, dielectrics, and their multilayers. The PLD technique, used broadly in research laboratories worldwide, is conceived as relatively simple, mainly because of the fact that the heating source for evaporation (ablation), i.e. a powerful laser, is located outside the process chamber. However, the actual processes and mechanisms that take place during laser ablation, in the plasma plume, and in the course of film growth on the substrate are highly dynamic and nontrivial. Furthermore, the volatile nature of lithium species in lithium-ion battery materials complicates dramatically the stoichiometric transfer from the dense target to the deposited thin film. My group has gained important knowledge on the synthesis of epitaxial thin films of various lithium-ion battery materials in recent years, demonstrating that control of the specific crystal orientation of epitaxial thin films results in dramatic differences in surface morphology, and corresponding electrochemical performance.

Epitaxial thin film technology will be applied to achieve complex heteroepitaxial microbattery architectures by combining the best performing high-voltage cathode, high-rate anode and solid-state electrolyte. Subsequently, the structural properties of the epitaxial multilayers will be studied by applying a wide range of characterization techniques available within my lab and the shared Nanolab of the MESA+ Institute for Nanotechnology, such as AFM, XRD, XPS, HAXPES, ICP, Raman, SEM, HRTEM and STEM-EELS. Furthermore, the electrochemical properties of the full solid-state microbattery systems will be investigated by multi-channel potentiostat/galvanostat systems using various electrochemical characterization techniques available in my lab, such as galvanostatic cycling, cyclic voltammetry, rate capability experiments, potentiostatic intermittent titration technique, and electrochemical impedance spectroscopy. The electrochemical performance of the individual thin film components will be studied as well in half cells against lithium metal with liquid electrolyte to determine the dependence of energy storage content, rate of charge, and cycle-life performance on the structure and composition for a specific epitaxial orientation. The interface mechanisms between the solid electrolyte and the adjacent epitaxial cathode and anode layers will be studied in more detail by operando analysis through advanced techniques, as part of ongoing (inter)national collaborations.

Requirements

- You are highly motivated and an enthusiastic researcher (F/M).
- You have a MSc degree in Chemistry, Physics or equivalent, with excellent experimental skills.
- You have a keen interest in Materials Science, Electrochemistry and bridging Chemistry and Physics.
- You have strong analytical skills and a keen interest in the interpretation of complex data.

- You are fluent in English.
- Experience with pulsed laser deposition, or other thin film deposition techniques, is preferred.

Information and application
For more information, please contact Prof. Mark Huijben (m.huijben@utwente.nl). The application should include a motivation letter emphasizing your research interest and motivation to apply for the Ph.D. position, a detailed CV, contact details of at least 2 referees, an academic transcript of B.Sc. and M.Sc. education and a TOEFL or IELTS score to verify sufficient mastering of the English language. An interview will be part of the selection procedure. Applications should be submitted to Prof. Mark Huijben (m.huijben@utwente.nl).

Conditions of employment
You will be appointed on a fulltime position for 4 years, with a qualifier in the first year, within a very stimulating scientific environment. The university offers a dynamic ecosystem with enthusiastic colleagues. Salary and conditions are in accordance with the collective labor agreement for Dutch universities.

- Monthly salary ranging from € 2.540- gross at the start to € 3.245,- gross in the 4th year.
- Excellent benefits including a holiday allowance of 8% of the gross annual salary, a yearly bonus of 8.3% and a solid pension scheme.
- A training program in which you and your supervisors will make a plan for additional suitable education and supervision.
- As a Ph.D. candidate you will be enrolled in the Twente Graduate School.
- We encourage a high degree of responsibility and independence, but also stimulate interaction and discussion with colleagues.

Employer

The University of Twente: We stand for life sciences and technology. High tech and human touch. Education and research that matter. New technology which leads change, innovation and progress in society. The University of Twente is the only campus university of the Netherlands; divided over five faculties we provide more than fifty educational programs. We have a strong focus on personal development and talented researchers are given scope for carrying out groundbreaking research.
We are an equal opportunity employer and value diversity at our company. We do not discriminate on the basis of race, religion, color, national origin, gender, sexual orientation, age, marital status or disability status. Because of our diversity values we do particularly support women to apply.

Within the TNW Faculty (Faculty of Science & Technology) of the University of Twente some 700 staff members and 2000 students are involved in training and research on the interface of chemical technology, applied physics and biomedical technology. Fields of application include sustainable energy, process technology and materials science, nanotechnology and technical medicine. Research, which enjoys a high profile both nationally and internationally, has been accommodated in the multidisciplinary research institutes: Mesa+ Institute, TechMed Centra and Digital Society Institute. The faculty works together intensively with industrial partners and researchers in the Netherlands and abroad and conducts extensive research for external commissioning parties and funders.

MESA+ Institute for Nanotechnology
The MESA+ Institute for Nanotechnology, which is one of the largest nanotechnology research institutes in the world with more than 500 researchers working together on cutting-edge research. The Thin Film laboratory of the MESA+ institute (under the shared responsibility of the involved PI's) is dedicated to the growth and characterization of thin films with exclusive deposition systems for the thin film growth of battery materials. A wide range of structural and electrochemical characterization techniques are present to enable ex-situ as well as in-situ analysis connected by the use of vacuum suitcases. The recent development of an unique lab-based multicolour HAXPES system in combination with the thin film infrastructure and the close proximity of many materials science experts within the 'Nanoelectronic Materials' cluster makes the University of Twente the perfect host institute.

Battery Centre Twente
At the University of Twente a lot of battery research is taking place within all faculties involving about 25 research groups and 100 researchers. The Battery Centre Twente was established to strengthen the interaction between

the researchers and to initiate new research programs on regional, national and European levels. In 2021 the University of Twente became a member of the Batteries European Partnership Association (BEPA) and is actively involved in the BATT4EU Partnership towards a competitive European industrial battery value chain. Energy storage and advanced manufacturing are strategic directions of the Eastern Netherlands region and actively strengthened, also across the border to the Nord-Rhein-Westfalen region in Germany. In the strategic partnership between the University of Twente and the Westfälische Wilhelms-Universität in Munster battery research is an important direction for collaboration. Strong contacts exist between the UT Battery Centre and the MEET battery institute of WWU as well the IEK-1 Electrochemical Storage department of Forschungszentrum Jülich. Furthermore, direct collaboration exist between Fraunhofer Forschungsfertigung Batteriezelle (FFB Munster) and Fraunhofer Innovation Platform at University of Twente.

VICI research program

Recently, the VICI personal research grant was awarded by NWO funding organization to Prof. Mark Huijben for the project titled 'Superior microbatteries by tailoring interfaces for an interconnected society'. This is a 5-year research program, which will involve three PhD students and one Postdoc. More information about ongoing research projects within the Huijben research group can be found on www.huijben.org .