PhD/Postdoc Position in Novel Li-operated Electrochemical Gas Sensors

We are looking for motivated students to work on the development and implementation of a cheap and scalable ceramic processing concept towards a fully sprayed Li-based device.

According to the World Health Organization, outdoor and household air pollution kill an estimated seven million people every year, accounting for one in eight deaths worldwide. Air pollution, an existential threat to Europe and the world, impacts the safety, comfort and health of humans and vegetation. It is the largest environmental cause of multiple mental and physical diseases and of premature deaths, especially among children, people with certain medical conditions and the elderly. With roughly 91% of the population living in urban areas and breathing polluted air, miniaturized detection units for air quality monitoring are urgently needed to preserve air quality, human health, and the environment. Current state-of-art commercial miniaturized gas sensors based on classical oxygen conductors are neither energy-efficient nor cost-effective. Realization and optimization of affordable, low-power gas sensors is a significant step towards battling climate and environmental challenges, transforming the EU into a modern, resource-efficient, and competitive economy.

Responsibilities and qualifications

The focus of this PhD/Postdoc project is to develop a new Li-operated potentiometric electrochemical gas sensor (PEGS) based on fast Li-ion conductors. The fast ion-conduction characteristics of Li-based materials unlock the possibilities of cost-effective, low-power, multi-sensing arrays with a fast response, new sensing-electrode chemistries, and an expanded scope of gases. The objective of the proposed PhD project is to investigate new materials, manufacturing routes and devices as well as gaining an in-depth understanding of the operational chemistry and physics in gas sensing.

The most widely used solid-state electrolytes in PEGS are O^{2-}-ion conductors including yttria-stabilized zirconia, tungsten-stabilized bismuth oxide, samarium-doped ceria, and Na^{+}-ion conductors such as sodium β-alumina and NASICON. Nevertheless, the relatively low mobility of O^{2-} and Na^{+} ions necessitate rather high operating temperatures above 500 °C to ensure fast response/recovery time, which translates into high energy consumption of the sensor. It remains surprising that despite their high conductivity and stability, Li-solid state oxide conductors have almost been neglected as electrolytes to replace classic oxygen conductors in sensors.

Your primary tasks include:

- Employ different processing methods (including but not limited to solid-state chemical synthesis, wet chemical-based approaches, high throughput synthesis techniques) to fabricate all-solid-state sensor structures.
- Characterize the bulk and surface structures and microstructures using various spectroscopic and microscopic techniques including but not limited to SEM, XRD, TEM, XPS.
- Evaluate the gas sensing properties and performance (sensitivity, stability, selectivity) towards fast-tracking sensing functionality using a variety of electrochemical techniques.
- Investigate and validate the sensing mechanism and rate limiting steps and study the degradation/evolution of the sensor chemistries under operating conditions.

Qualified applicants must have:

- A master's degree/PhD in chemistry, chemical engineering, materials science, or similar is required.
- Hands-on mentality, independent and diligent operation is welcomed.
- Excellent at working independently, taking initiatives, responsibilities, able to plan and carry out multi-tasks.
- Good English proficiency, both written and spoken.

It is beneficial if you have taken courses or carried out studies on

- Electrochemistry, electrochemical engineering, electrochemical sensors, solid state chemistry, solid-state processing, or similar
- Synthesis of Li-based ceramic materials via wet chemical techniques and fabrication of all solid-state devices.
- Characterization techniques such as XRD, Raman, IR, TEM, XPS.
- Experience (also for setup design) using CAD software (e.g., Solidwork), Python, MATLAB, or similar.

The following papers are a good starting point to get familiar with the topic:

1. M Balaish, JLM Rupp, Widening the Range of Trackable Environmental and Health Pollutants for Li-Garnet-Based Sensors, Advanced Materials, 2021; https://doi.org/10.1002/adma.202100314
2. M Balaish, JLM Rupp, Design of triple and quadruple phase boundaries and chemistries for environmental SO 2 electrochemical sensing, Journal of Materials Chemistry A, 2021

3. M. Struzik, I. Garbayo, R. Pfenninger, J.L.M. Rupp, A Simple and Fast Electrochemical CO2 Sensor based on Li7La3Zr2O12 for Environmental Monitoring, Advanced Materials, 30, 1804098 (2018)

Application procedure and assessment

The assessment of the applicants will be made by Dr. Moran Balaish. Please send your application in English as **one PDF file to** moran.balaish@tum.de no later than **12 September 2023 CET**. The file must include:

- A motivation letter from the applicant (cover letter).
- Curriculum vitae.
- Grade transcripts and BSc/MSc/PhD diploma (in English) including official description of grading scale.
- (Optional) Documents showing relevant competencies and experience.

The research group is in the chemistry department of the Technical University of Munich (https://ecm-tum.de/). All interested candidates irrespective of age, gender, race, disability, religion, or ethnic background are encouraged to apply.

Dr. Moran Balaish
Junior Research Group Leader
Technical University of Munich
Lichtenbergstr. 4, 85748 Garching b. München
balaish@tumint-energy.de
moran.balaish@tum.de
https://ecm-tum.github.io