

1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: Studies on the synthesis and characterization of carbon materials for use in sodium ion batteries

Project goals:

- To explore relation between the chemical structure of carbon materials (morphology and kind of carbon network, presence of heteroatoms, surface modification) and their electrochemical activity and electroadsorption ability.
- Solid-state spectroscopic, spectroelectrochemistry and microscopic investigation (MAS NMR, TEM, SEM, EDX, PEELS, XPS, XRD, IR, Raman).
- to strengthen NCU-TUD-GUT* cooperation

*NCU Nicolaus Copernicus University, TUD Technische Universität Darmstadt, GUT Gdańsk University of Technology

Outline:

There is an urgent need to develop a highly efficient, low-cost alternative to the now ubiquitous lithium-ion batteries. This project aims to develop, investigate and characterise novel, stable and cost-efficient electrodes for Na-ion battery (NIB). The knowledge and experience in materials chemistry and electrochemistry, as well as access to highly specialised equipment (TEM, MAS-NMR, Raman spectroelectrochemistry), is required for the successful realisation of the planned studies whose purpose is determination of Na-storage host and microstructural stability.

Work plan:

1. Synthesis and electrochemical characterisation of Na₃V₂(PO₄)₃/nanocarbon composite cathode (GUT). Physicochemical and electrochemical characterisation of the composites (NCU).
2. Synthesis and electrochemical characterisation of Sn/C/SiOC composite anode (TUD). Material characterisation, electrochemical properties (NCU).
3. Investigation of Na-Storage mechanisms and microstructure of electrode materials (NCU).

Literature:

1. D. Vrankovic, M. Graczyk-Zajac, C. Kalcher, J. Rohrer, M. Becker, C. Stabler, G. Trykowski, K. Albe, R. Riedel, Highly Porous Silicon Embedded in a Ceramic Matrix: A Stable High-Capacity Electrode for Li-Ion Batteries, *ACS Nano*, 11 (2017) 11409-11416.
2. A.P. Nowak, A. Lisowska-Oleksiak, K. Siuzdak, M. Sawczak, M. Gazda, J. Karczewski, G. Trykowski, Tin oxide nanoparticles from laser ablation encapsulated in a carbonaceous matrix – a negative electrode in lithium-ion battery applications, *RSC Advances*, 5 (2015) 84321-84327.
3. K. Wissel, D. Vrankovic, G. Trykowski, M. Graczyk-Zajac, Synthesis of 3D silicon with tailored nanostructure: Influence of morphology on the electrochemical properties, *Solid State Ionics*, 302 (2017) 180-185.

Required initial knowledge and skills of the PhD candidate:

Understanding of materials synthesis and chemistry

Predisposition to experimental work

Manual skills for operating research equipment (Raman, Ir, SEM, TEM, XRD, NMR)

Practical communication skills in English, knowledge of German would be an advantage

Expected development of the PhD candidate's knowledge and skills:

Understanding of carbon material science

Ability of experimental work with carbon materials, including nanomaterials

Skills of operating research equipment and results processing

Experience in domestic and foreign scientific cooperation

Communication skills in English at conferences and in writing publications