RUHR UNIVERSITÄT BOCHUM RUB

CSC-RUB PhD Project Proposal

Title: Designing Power-to-X Applications

Sector of research: Chemistry/Materials Science/Engineering

Degree awarded: PhD

Keywords: Materials synthesis & characterization, Process engineering, Membrane electrode assemblies, metal sulfides & oxides, Hydrogen evolution reaction, CO_2 & N_2 reduction reaction, Water oxidation,

Supervisor of PhD project: Prof. Dr. Ulf-Peter Apfel

Research focus of supervisor:

The Apfel group is located at the Faculty of Chemistry and Biochemistry as well as the Fraunhofer UMSICHT, department of electrosynthesis, and consists of an interdisciplinary team of chemists and engineers. The group is mainly interested in the activation of biologically and industrially relevant small molecules such as H_2, N_2, O_2, CO and CO_2. Especially the formation of hydrogen, the electrochemical conversion of CO_2 or N_2 and (bio-)electroorganic transformations are main topics and projects. These projects involve the synthesis of novel homogenous and heterogenous electro- and photocatalytic materials including their scale up. Along this line, the subsequent preparation of industrial relevant electrodes based on the novel materials is in the focus of the groups research. In addition, the group designs new electrochemical reactors for continuous operation modes.

So overall the group is active in the fields of inorganic and technical electrochemistry with a strong focus on application driven research and technology transfer.

Publications:

H-index 29; 99 publications in the last 5 years

1.) B. Konkena, K. junge Puring, O. Khavryuchenko, I. Sinev, S. Piontek, M. Muhler, W. Schuhmann, U.-P. Apfel, *Nature Commun.* **2016**, 7:12269, DOI: 10.1038/ncomms12269. Pentlandite Rocks as Highly Efficient, Sustainable and Stable Electrocatalysts for H_2 Generation.

2.) S. Piontek, K. junge Puring, D. Siegmund, M. Smialkowski, I. Sinev, B. Roldan Cuenya, U.-P. Apfel, *Chem. Sci.* **2019**, *10*, 1075–1081. Bio-Inspired Design: Bulk Iron-Nickel Sulfide Allows for Efficient Solvent-dependent CO_2 Reduction.

3.) K. junge Puring, O. Evers, M. Prokein, D. Siegmund, F. Scholten, N. Mölders, M. Renner, B. Roldan Cuenya, M. Petermann, E. Weidner, U.-P. Apfel, *ACS Catalysis* **2020**, *10*, 12783-12789. Assessing the influence of supercritical carbon dioxide on the electrochemical reduction to formic acid using carbon-supported copper catalysts.

4.) K. junge Puring, D. Siegmund, J. Timm, F. Möllenbruck, S. Schemme, R. Marschall, U.-P. Apfel, *Advanced Sustainable Systems* **2021**, 5 (1), 2000088. Electrochemical CO_2 reduction: Tailoring catalyst layers in gas diffusion electrodes.

5.) D. Siegmund, S. Metz, V. Peinecke, T. E. Warner, C. Cremers, A. Grevé, T. Smolinka, D. Segets, U.-P. Apfel, *J. Am. Chem. Soc. Au* **2021**, 1, 527. Crossing the Valley of Death: From Fundamental to Applied Research in Electrolysis

Summary of research plan:

Background: The electrochemical conversion of small gaseous molecules like CO_2 and N_2 is an important and tough undertaking and urgently needed to establish a sustainable future based on P2X-processes. We recently found that metal sulfides are potential catalysts to convert these small

molecules. Likewise, we could show that beside the catalyst, the electrode composition as well as the process conditions play a pivotal role in these processes and form an inseparable unit. Thus, catalysts, electrodes and reactor systems must be developed as a whole to allow for a future transfer to an application. The fundamentals to do so, are yet not well understood and require increased research efforts.

Study objective: The aim is to improve the understanding of the interrelationship between catalysts, their preparation and crafting into multi-component electrodes as well as their electrochemical performance for the electrochemical CO_2 and N_2 reduction processes.

Expected Results: The novel insights that will be obtained in this project will not only advance the knowledge base into the field of chemistry and materials science but will also enable a more knowledge-based assembly of electrodes and reactors fit for Power-to-X applications.

Methods: For details on methods available in the group, please check out www.ruhr-uni-bochum.de/smallmolecules & www.umsicht.fraunhofer.de

Candidate Requirements:

- an excellent master's degree in chemistry, materials science, or process/chemical engineering
- solid knowledge of electrochemistry and materials chemistry
- a high level of spoken and written English (IELTS band score of 6.5 or higher)

Motivation for CSC application The successful candidate will be working in the Department of Chemistry and Biochemistry at Ruhr University Bochum as well as at the Fraunhofer Institute UMSICHT, which together house a large and comprehensive suite of equipment dedicated to power-to-X technologies and have a strong international reputation. She or he will have access to a world-class set of laboratories and networks. My research group collaborates intensely with international universities and research institutes such as University of Paris, University of Bern, Shaanxi Normal University, University of Leicester, National Tsing Hua University etc. We aim to provide students with an international and interdisciplinary platform to conduct high-level scientific research.