Experimental Introduction to Electrochemistry

Supervisors

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Number of Candidates

3

Backgrounds of Candidates

Candidate 1: The candidate preferentially has an affinity for materials properties, with some laboratory experience. An interest and experience in coding is also advantageous. Familiarity with SEM and XRD are desirable.

Candidate 2: The candidate has an interest in materials properties with some laboratory experience. The ability to conduct researched in a careful and planned manner is advantageous. Familiarities with synthesis, sintering, SEM and XRD are desirable.

Candidate 3: The candidate has an interest in materials properties with some laboratory experience. Basic understanding of electrochemistry is also advantageous.

Project Descriptions

The three projects offered yield an introduction to the efforts conducted at the group of Electrochemistry to research materials for renewable energy applications.

Project 1: The first project concerns tantalum nitride (Ta_3N_5) in its undoped form as well as doped versions of itthat are thought to improve various aspect of the photocatalyst. Within this project the student will measure the ion exchange from nitrogen to oxygen by thermogravimetry measurements and gas phase analysis. Analyzing the results of the different measurements will also be in focus and yield an understanding of how doping of Ta_3N_5 changes its stability at elevated temperatures.

Project 2: The second project comprisesspark plasma sintering (SPS). SPS is a method to manufacture high-density ceramics and metals by inducing high pressure and current. The method is utilized to sinter materials that are difficult to sinter with common furnaces. The high current imposed on the sample generates a local plasma region between particles, which preserves the nano- or microstructures in the sintered product. However, multiple reports in literature show inconsistent quality of sintered proton conducting oxides by SPS [1, 2]. It is therefore important to establish the preferred parameters for SPS to obtain acceptable samples from the method.

In this project, the student will sinter $BaZr_{0.4}Ce_{0.4}Y_{0.2}O_{3-\delta}$ (BZCY) pellets under different conditions at the new spark plasma sintering instrument. This comprehensive study will involve changing all the different parameters a user may choose during spark plasma sintering, as well as characterization via SEM and XRD. Finally, the goal will be to create a guide for similar studies on different materials in the future.

Project 3: The third project includes rotating disk electrode (RDE) measurements on various complex oxides. Materials at the group for Electrochemistry are often tested with a specific use in mind, e.g., methane reformation, or high temperature electrochemical cells. However, often these samples are not further investigated for different purposes. Previous studies from the group have shown that these materials can have an important and crucial role in developing novel electrode for alkaline electrolysis [3, 4]. The student will learn how to set up, run and evaluate RDE measurements. These measurements yield insights into different reaction mechanisms and unlock knowledge of functional properties.

1. Wallis, J., et al., *The influence of the sintering temperature on BaZr0·7Ce0·2Y0·1O3-δ proton conductors prepared by Spark Plasma Sintering.* Ceramics International, 2021. **47**(11): p. 15349-15356.
2. Wallis, J., et al., *Structural and electrical properties of BaZr0.7Ce0.2Y0.1O3−δ proton conducting ceramic fabricated by spark plasma sintering.* Solid State Ionics, 2020. **345**: p. 115118.
3. Andersen, H., et al., *A highly efficient electrocatalyst based on double perovskite cobaltites with immense intrinsic catalytic activity for water oxidation.* Chemical Communications, 2020. **56**(7): p. 1030-1033.
4. Zhu, J., et al., *Double Perovskite Cobaltites Integrated in a Monolithic and Noble Metal-Free Photoelectrochemical Device for Efficient Water Splitting.* ACS Applied Materials & Interfaces, 2021. **13**(17): p. 20313-20325.