Material-structure-property relations in bifunctional electrodes for metal oxygen batteries

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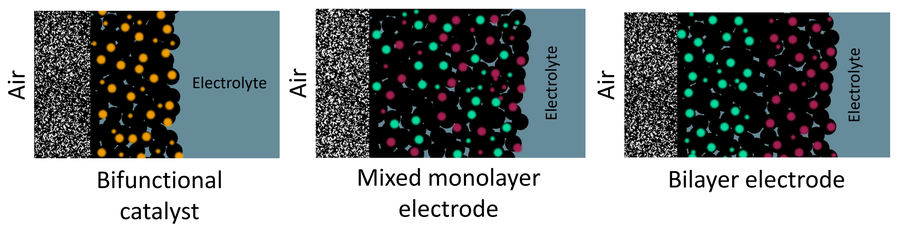
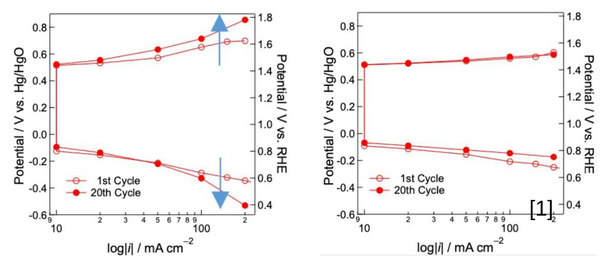
Motivation

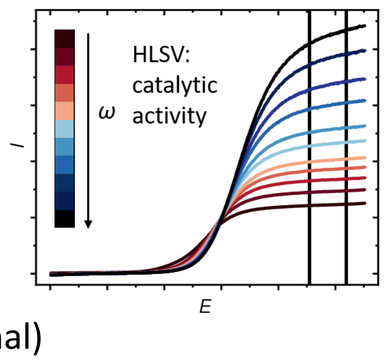
- Overpotential at the cathode of, e. g. zinc oxygen batteries is still too high; bilayer electrode are discussed as one viable option to overcome this shortcoming
- Bilayer & mixed monolayer electrodes contain two different catalysts with high activity for each specific reaction
- Ikezawa et al. showed:[1]
  - better durability for bilayer electrode than for mixed monolayer
  - lower overpotential when separating the catalysts into different layers
- Project goal (joint DFG project between TU Braunschweig and Tokyo Institute of Technology):
  - To get a better understanding of bilayer catalysts in a battery system for further optimization
  - Charge/discharge efficiency of 70 % in zinc oxygen battery application; operating time of more than 750 h





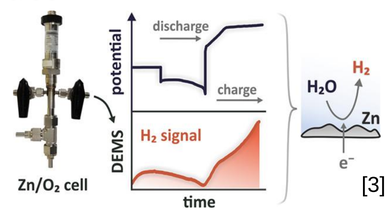
Operando Analysis

- Hydrodynamic linear sweep voltammetry
  - Catalyst activity
- Acoustic emission to detect
  - Gas formation during operation
- Gas Analysis
  - Degradation products
- Nonlinear impedance spectroscopy
  - Identify the rate determining processes (unwanted & intentional)



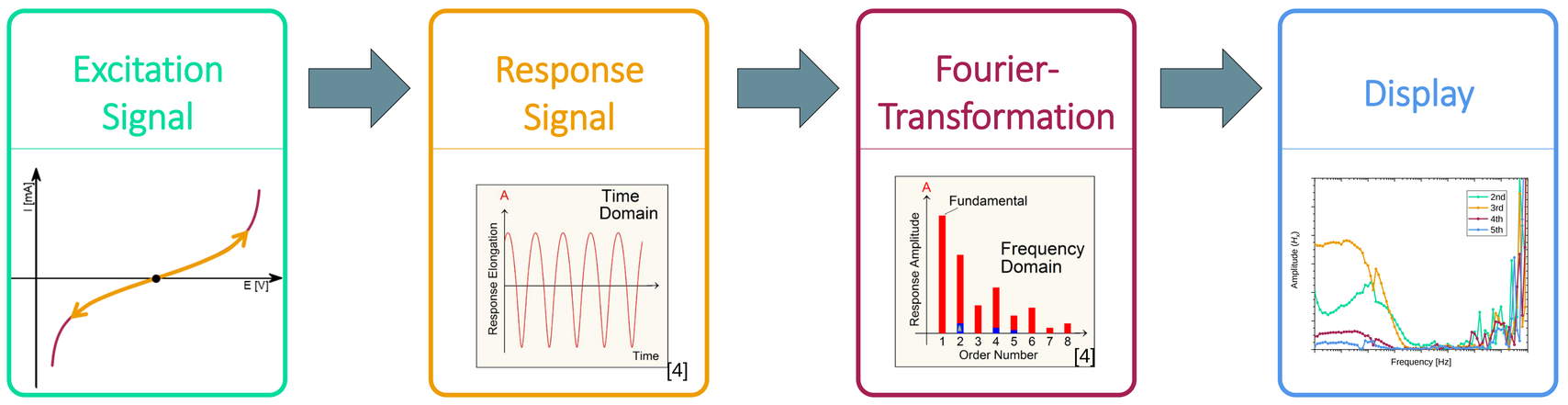
Full Cell Benchmarking

- Benchmarking of different bilayer electrodes
  - Charge/discharge efficiency
  - Operating time
- Pressure difference testing for cathode
  - Closed compartment cell with pressure sensor to monitor evolved gases
- Post-mortem analysis
  - Raman
  - FIB-SEM



Nonlinear Frequency Response Analysis

- Electrochemical systems show nonlinear (NL) behavior
- EIS is missing NL information
- NFRA obtains NL information and higher harmonics
- How can this method be used to qualify different processes that appear and disappear with time in certain domains?
- How can we use this to evaluate the stability and performance of the electrodes in a full cell?



Excitation with large amplitude → unfiltered response signal contains nonlinearities

FFT transforms from time into frequency domain. The higher harmonics from the FFT can be plotted against the frequency

References

[1]: A. Ikezawa, K. Seki, H. Arai, *Electrochim. Acta,* **2021**, *394*, 1-10.
[2]: www.mtixtl.com, **2023.**
[]: S. Dongmo et al., *ACS Omega,* **2020,** *5*, 626-633
[4]: Zahner Elektrik, **2023.**

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