INW-1 presentation to Horizon Europe Networking Forum 2025

BRUSSELS

OCTOBER 16, 2025 I JIMUN YOO

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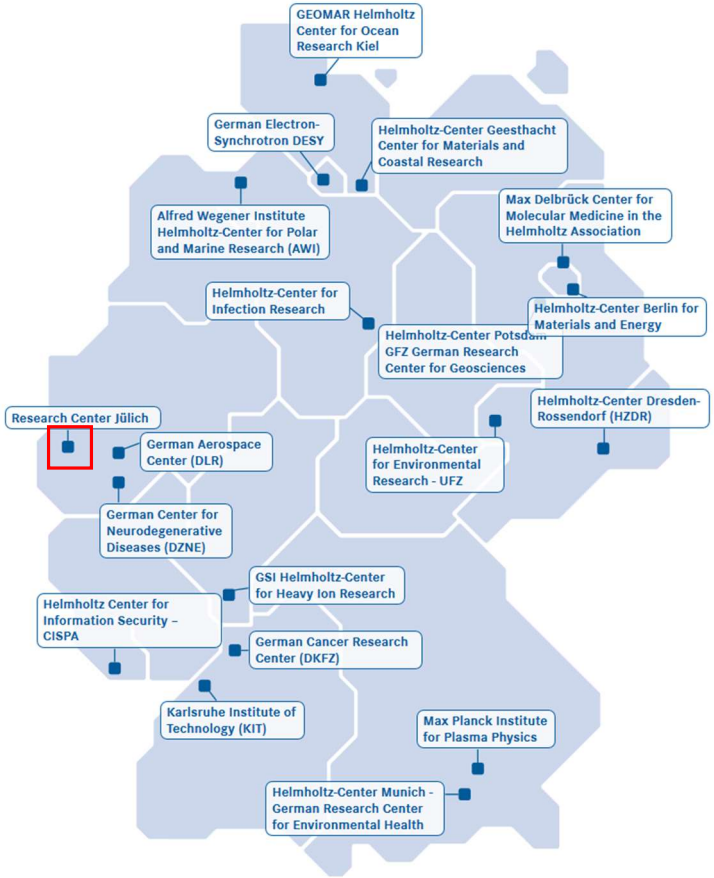
JÜLICH
Forschungszentrum

Introduction: Forschungszentrum Jülich



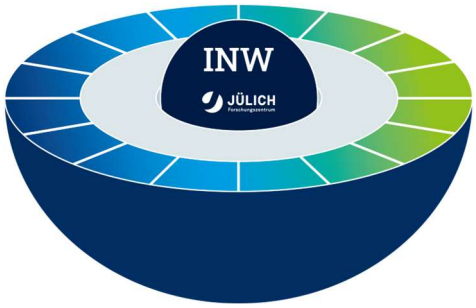
- A member of Helmholtz Association of German Research Centers
- Europe's largest interdisciplinary research center
- Largest scientific organization in Germany
- 14 Institutes / 7,000 Employees / One of the largest campuses in Europe
- Main research: **Energy** / Information / Bioeconomy & Sustainability

Introduction: Institute for a Sustainable Hydrogen Economy (INW)

HC·H2 Helmholtz-Cluster Wasserstoff

- Helmholtz-Cluster for Hydrogen Project by Federal German Government
- European largest *Structural Change* project: From **Coal** to **Hydrogen**

H2 Innovation center =
Institute for a sustainable hydrogen economy (INW)
of Forschungszentrum Jülich (FZJ)



Cooperations with core partners

RWTH Aachen University
FH Aachen
Brainergy Park Jülich

H2 Demonstration region
With partners from industry, academia & municipalities

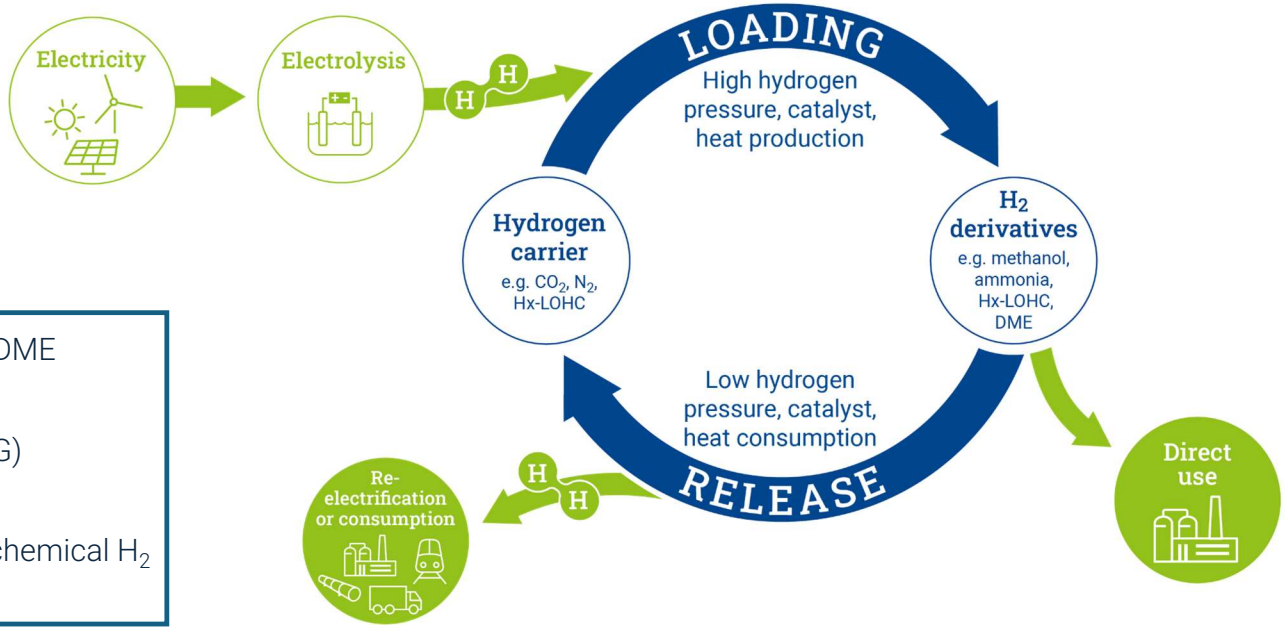
Innovative demonstrators
10 to 15 plants for innovative **hydrogen technologies** in the Rhenish mining region

Demonstration
of different technological characteristics

JÜLICH Forschungszentrum

Introduction: Institute for a Sustainable Hydrogen Economy (INW)

- Chemical hydrogen storage for infrastructure-compatible technology
- Catalytic reaction for hydrogen loading (hydrogenation) & releasing (Dehydrogenation) process



- MeOH and DME
- NH_3
- CH_4 (as SNG)
- LOHC
- Upcoming chemical H_2 carriers

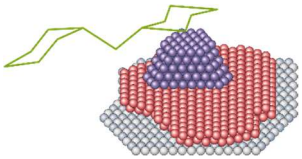
Introduction: Institute for a Sustainable Hydrogen Economy (INW)

Institute for a sustainable hydrogen economy **(INW)**

INW-1 Prof. Hans-Georg Steinrück

Catalytic interfaces

- Fundamental reaction mechanism at catalytic interface
- Identificaiton of structural descriptor for activity/stability/selectivity



INW-2 Prof. Regina Palkovits

Catalyst materials

- Optimization of catalyst/support structure
- Optimization of mass/heat transfer at the catalyst pellet

INW-3 Prof. Peter Wasserscheid

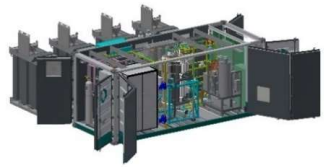
Reaction technology

- Hydrogen supply and discharge
- Thermal management

INW-4 Prof. Andrea Peschel

Process and systems engineering

- Process synthesis and analysis
- Experimental testing from laboratory to pilot plant
- Key technology & technology platforms



Introduction: INW-1 Catalytic Interface

INW-1 Prof. Hans-Georg Steinrück

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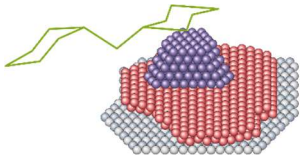
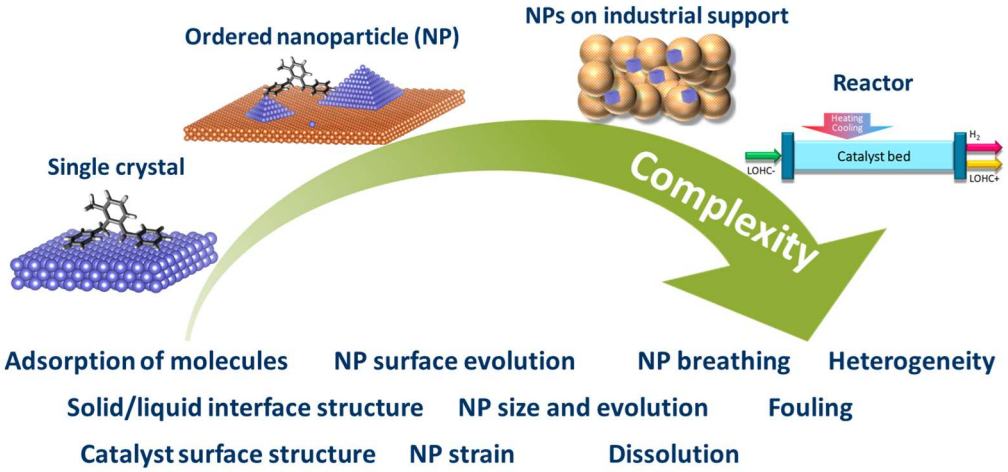


- Atomic- to meso-scale mechanisms and processes with a focus on interfacial and transport phenomena



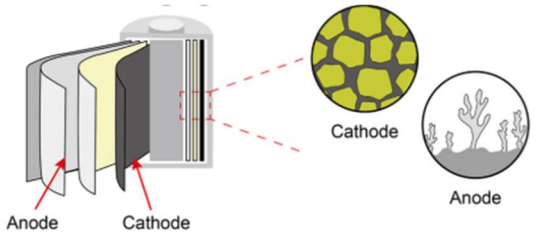
Methods: X-ray scattering, spectroscopy, microscopy @ laboratory, synchrotron, FEL X-ray sources **under reaction conditions**

Foundational and scalable understanding across scales → *Rational design of and new concepts for improved materials*

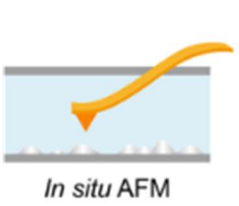
Why Operando?

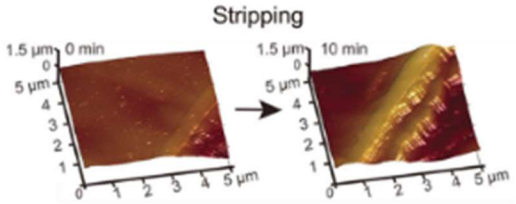
Q. How does sea turtle swim?

ex situ

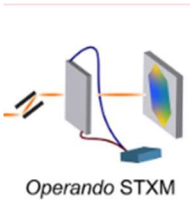


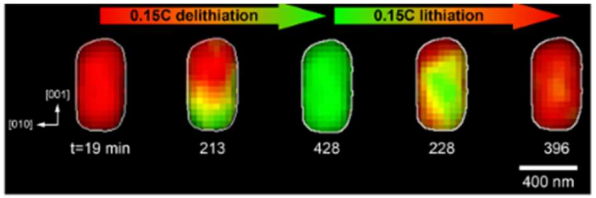
in situ





operando



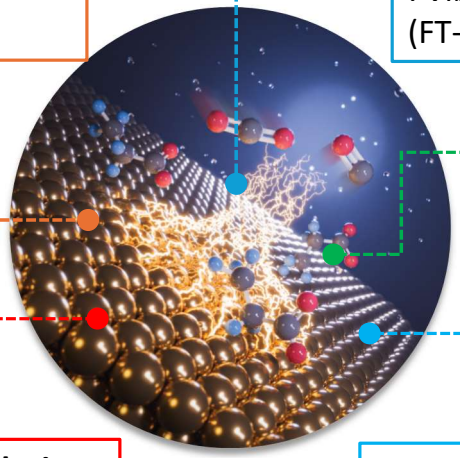


Multi-modal Operando analytic platform for electrochemical interface

❖ **Electronic structure change**
: X-ray photoelectron/ absorption spectroscopy

❖ **Molecular intermediate**
: Vibrational spectroscopy (FT-IR, Raman)

❖ **Local heterogeneity**
: Scanning probe microscopy (AFM, TERS)



❖ **Atomic structure evolution**
: X-ray scattering/diffraction

❖ **Degradation/Side reaction**
: Mass spectrometer

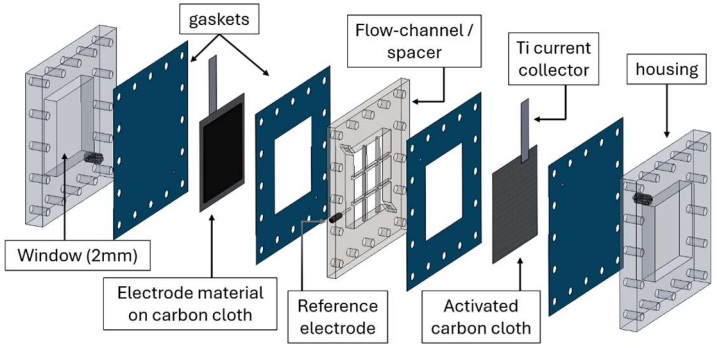
Core competencies

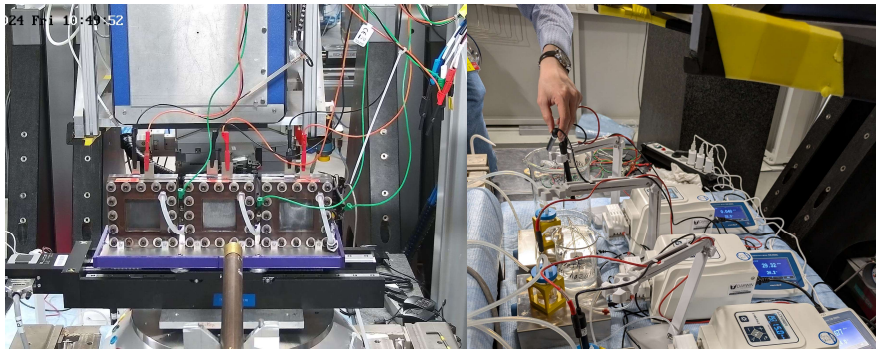
- Atomic/molecular scale phenomena at electrochemical interfaces
- Operando and in situ studies
- Model systems
- Batteries, desalination, Li extraction
- Custom cell design
- X-ray methods
- Advanced data analysis
- CV modelling

➢ What we can contribute:

1. Highly resolved characterization of (electro)chemical interface system under operation condition (operando)
2. Identification of key structure feature or parameter as guideline for optimized material or system design
3. Diagnosis of failure mechanism of materials within operating device systems

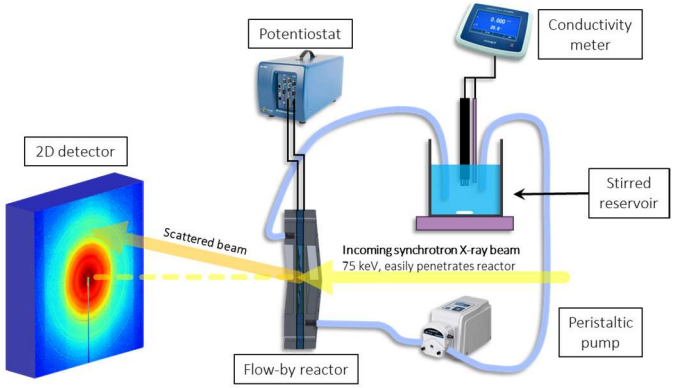
Example: Electrochemical Li^+ extraction process at ESRF (Beamline: ID31)

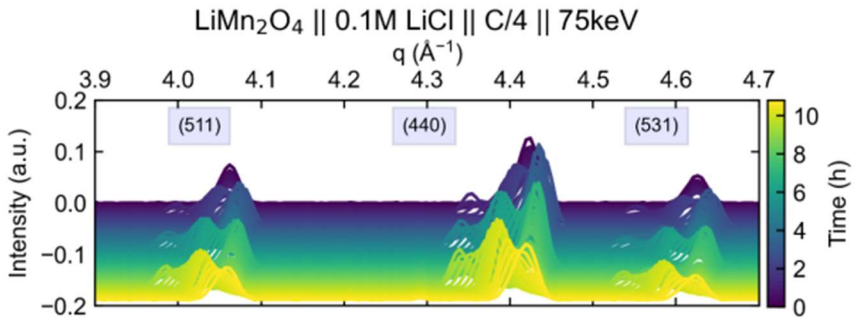




Andreas Kuhlmann

Marten Huck

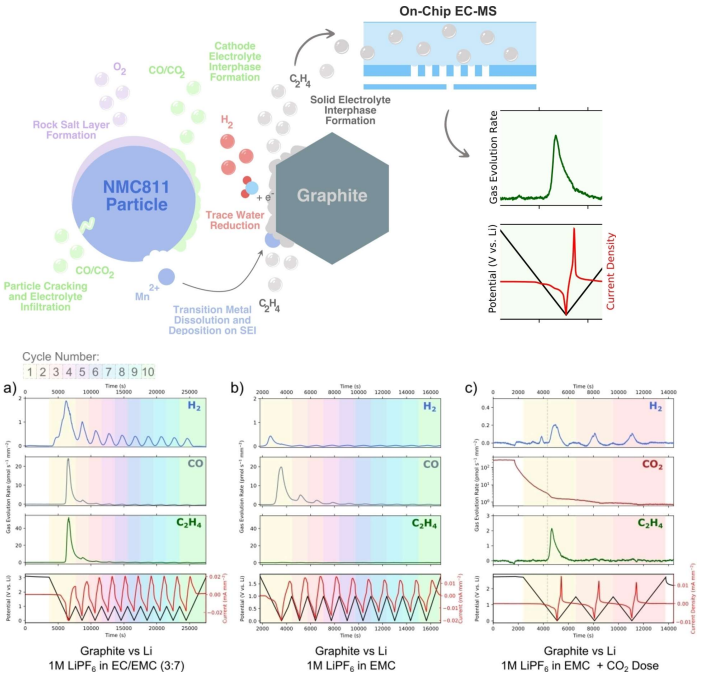




On site installation of flow-type single cells at ESRF ID31 / Operando high-energy XRD microscopy to track site/potential-dependent LMO phase

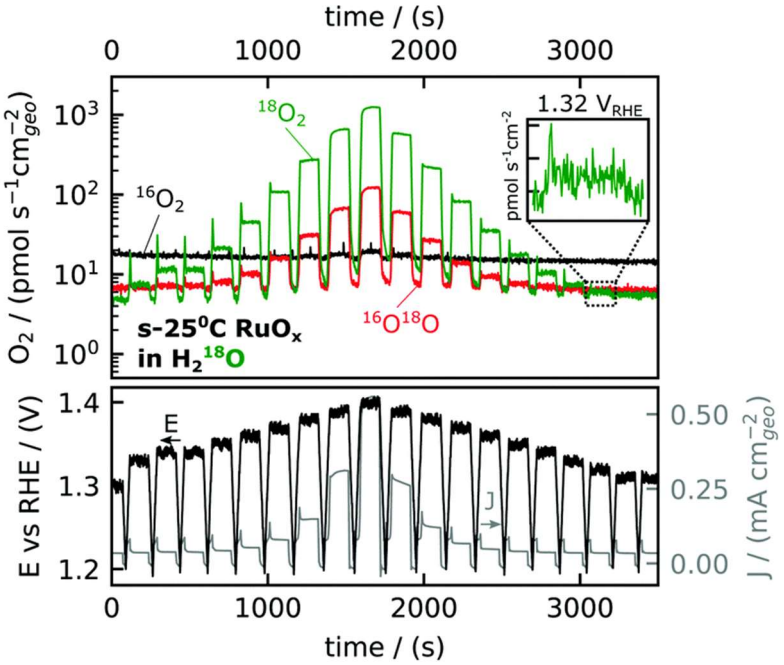
Example: Electrochemical-Chemical coupled side reaction within device

Gas evolution in battery system



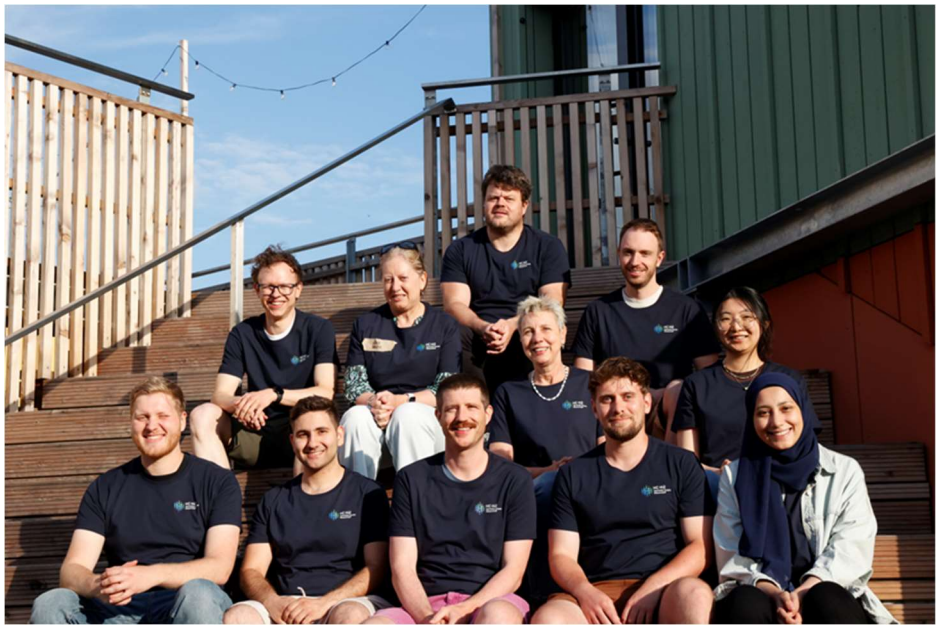
Angew. Chem. Int. Ed. 2023, *63*, 6, e202315357

Electrolyzer catalyst failure mechanism



Energy Environ. Sci. 2022, *15*, 1988-2001

Acknowledgement



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