Metal Transition-based catalyst to alkaline Oxygen Evolution Reaction

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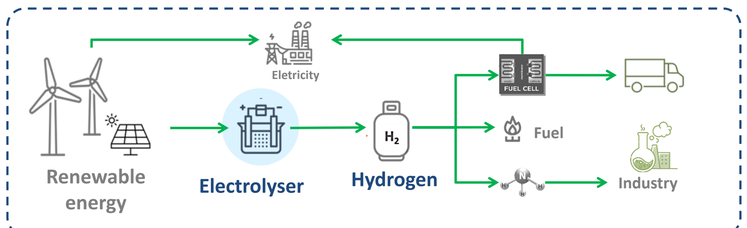
Motivation

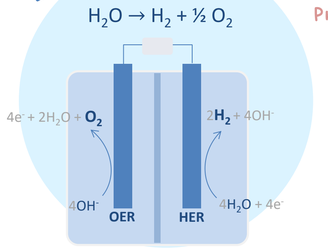
Hydrogen production by water electrolysis



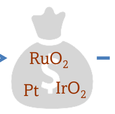
H_2 production

Water splitting

$H_2O \rightarrow H_2 + ½\ O_2$



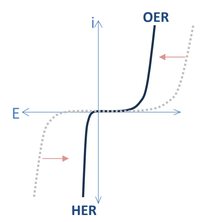
Problem



need for catalysts based on non-noble metals

How to investigate?

Electrocatalysis



Alternatives to OER

Metal transition-based catalyts

Why?

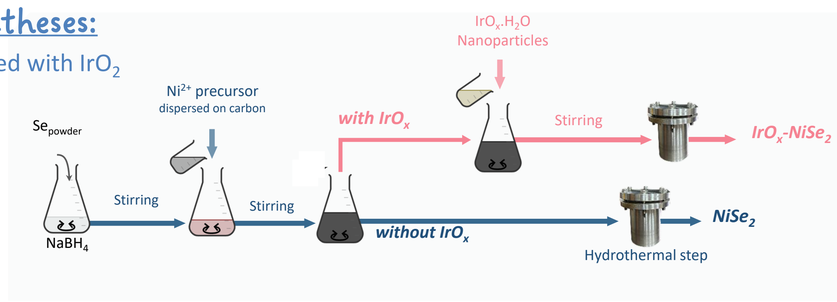
MOOH ↑ MX_2

- ✓ Activity to OER reaction
- ✓ Formation of stable Metal-OOH phase

Synthesis and Characterization

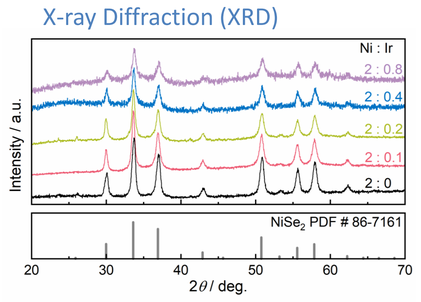
Hydrothermal Syntheses:

Ex.: Nickel Selenide modified with IrO_2

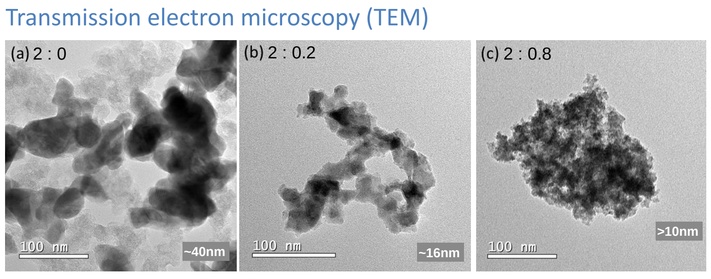


Strutural Analysis

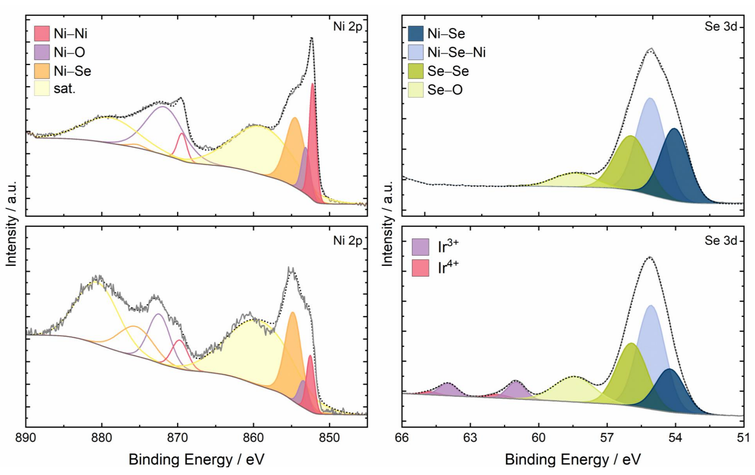
X-ray Diffraction (XRD)



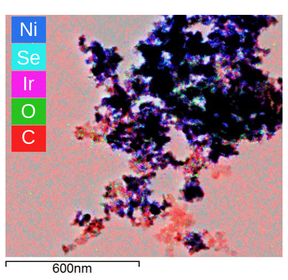
Transmission electron microscopy (TEM)



X-ray photoelectron spectroscopy (XPS)

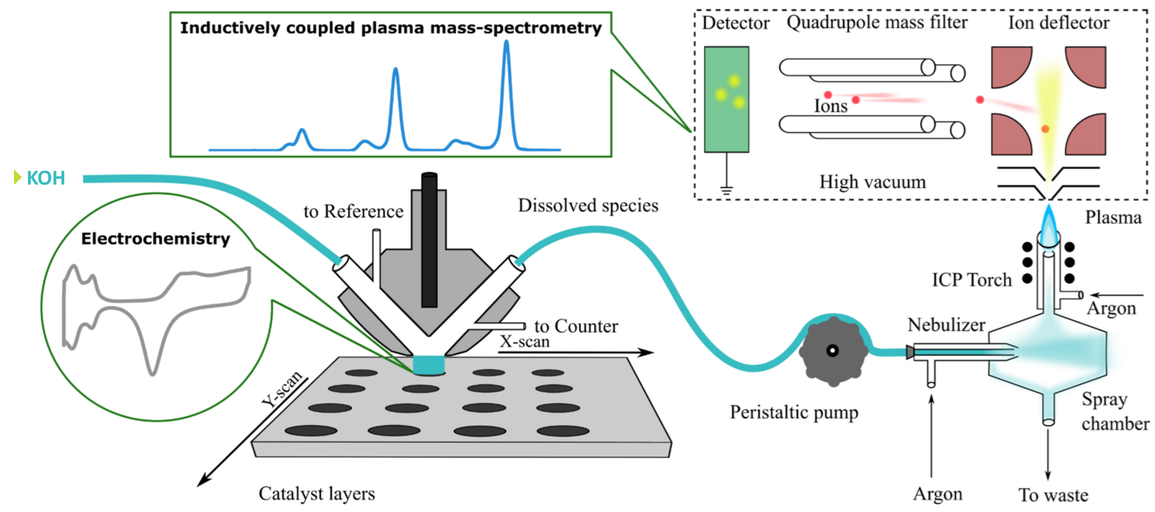


Energy-dispersive X-ray spectroscopy (EDS)



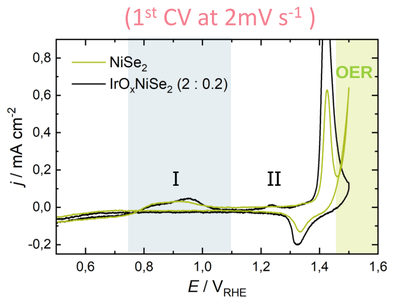
Stability analysis using scanning flow cell coupled (SFC) to an Inductively coupled plasm mass spectrometer (ICP-MS)

Online analysis

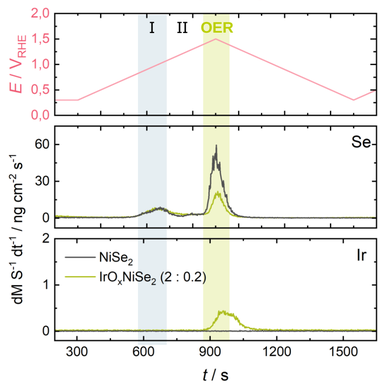


Formation of NiOOH to Chalcogenides Metal Transition

Cycilc Voltametry
(1st CV at 2mV s^{-1})



Dissolution analysis by SFC-ICP-MS



I
$NiSe_2 + 15OH^- \rightarrow NiOOH + 2SeO_3^{-2} + 7H_2O + 11e^-$

II
$NiSe_2 + 19OH^- \rightarrow NiOOH + 2SeO_4^{-2} + 9H_2O + 15e^-$

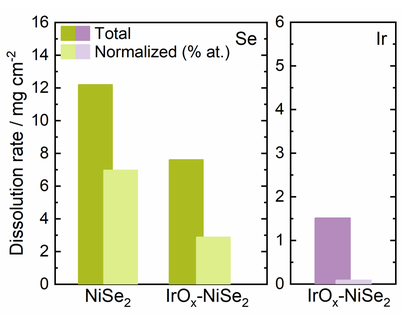
E > 1.5 V_{RHE} is destructive to the catalyst

Se_2^{-2} is dissolved to form the active phase

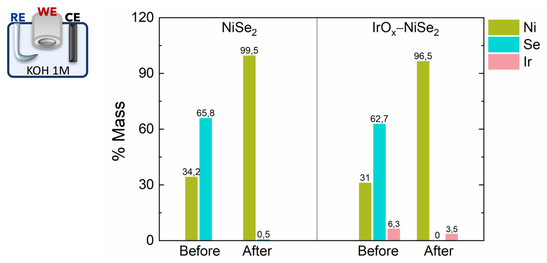
Stability Analysis (Long term conditions):

Methos: Accelerated stress tests
(500 cycles of CV at 100 mV s^{-1})

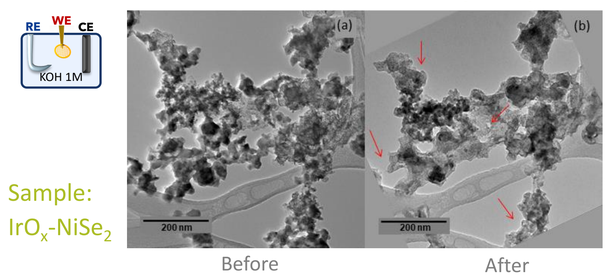
1. Total dissolution by ICP-MS during the stability analysis



2. Characterization by EDS after the stability analysis



3. Identical-Location-TEM after the stability analysis



Sample: IrO_x-$NiSe_2$

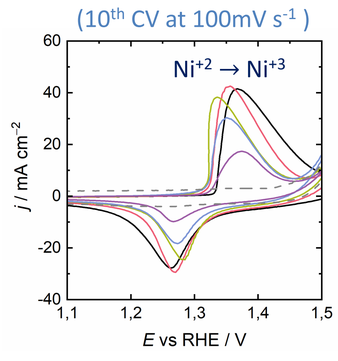
Before After

Electrochemical Analysis to OER Activity

Rotating disc electrode Analysis

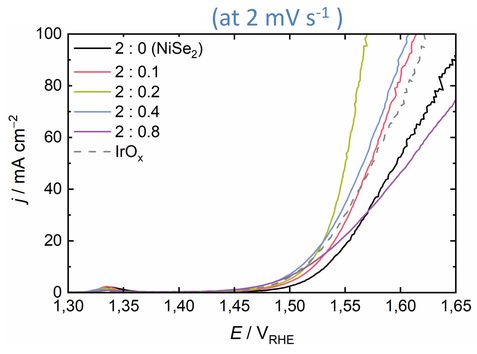
RE – Reference Electrode
CE – Counter Electrode
WE – Work Electrode (catalyst)

Cycilc Voltametry (CV)
(10th CV at 100mV s^{-1})



Ni oxidation
Structural modification to form the active phase Ni-OOH

Linear Scan Voltammetric
(at 2 mV s^{-1})



Higher amount of IrO_x decreases the potential for onset potential OER

Lower proportion of IrO_x showed lower potentials at high current densities

Summarize

- Electrocatalysis is key to developing new catalysts for OER and boosting the production of green hydrogen.
- Selecting the appropriate synthesis method and incorporating modifications to the material's composition or structure are critical steps for enhancing catalytic performance
- Material characterization is crucial for understanding catalyst structures and their impact on catalytic activity
- Advanced analytical techniques, such as online ICP-MS, provide valuable insights into the dissolution behavior of transition metal-based catalysts and their relationship with electrochemical oxidation or reduction processes during the OER.

References

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[5] Dionigi, F., Zhu, J., Zeng, Z., ... & Strasser, P. (2021). Angewandte Chemie, 133(26), 14567-14578.

Acknowledgment

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