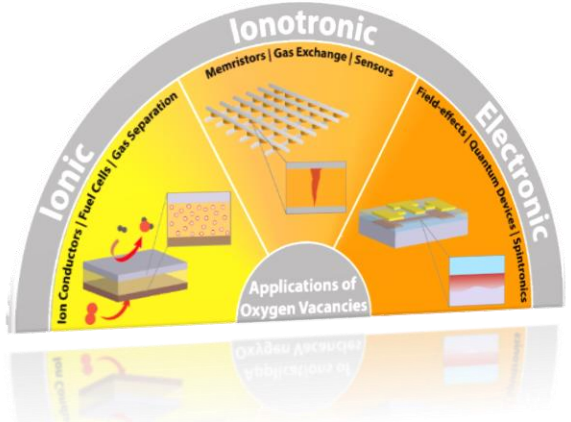
JÜLICH
FORSCHUNGSZENTRUM

Space-charge-mediated phenomena at oxide interfaces for electrochemical water splitting

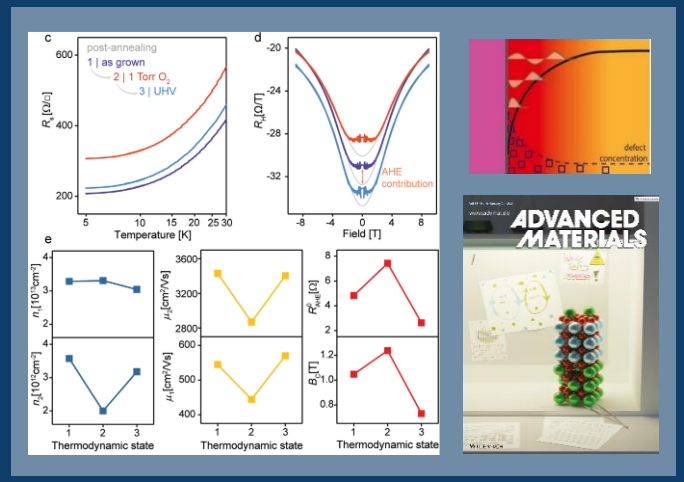
Felix Gunkel, M. L. Weber, L.Heymann, A. Kaus, C. Bäumer



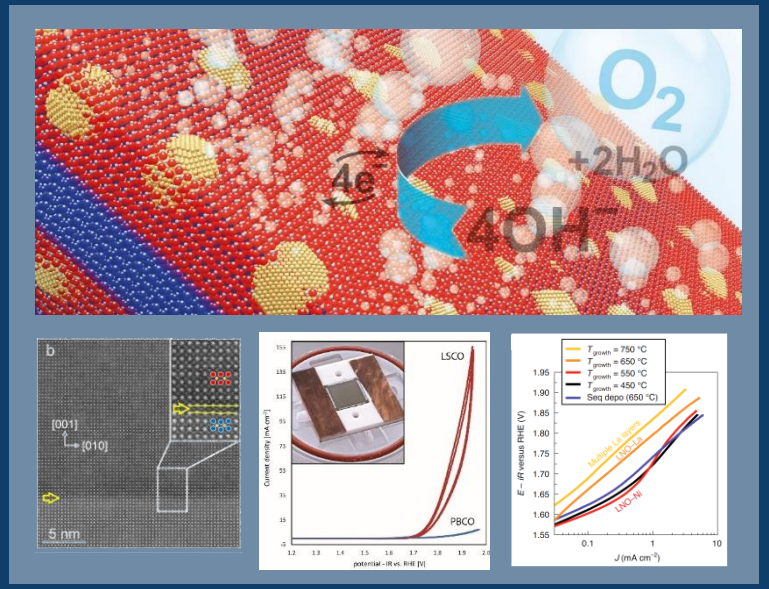
TAILORED OXIDE INTERFACES @PGI-7

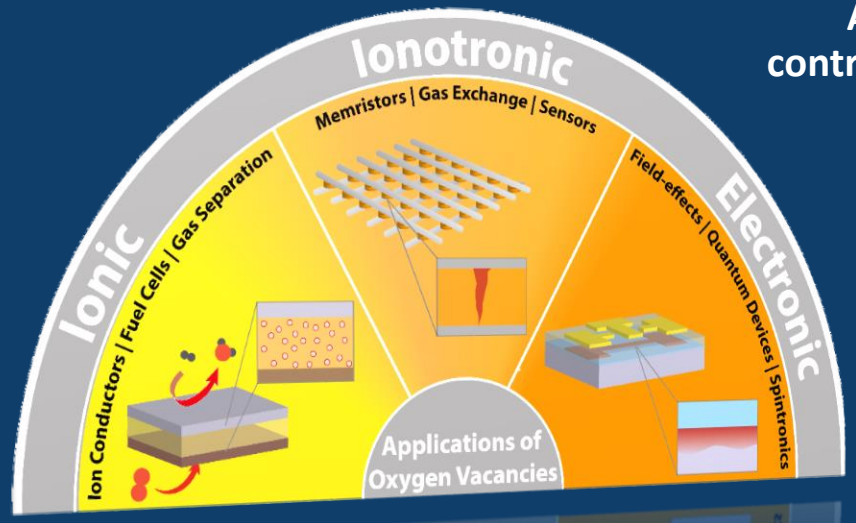
JÜLICH FORSCHUNGSZENTRUM

Ion transfer across tailored hetero-interfaces in oxide electronics



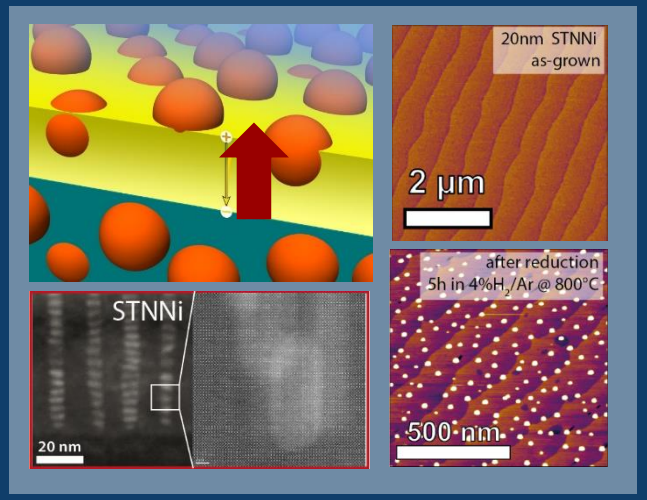
Atomistic understanding and control of water splitting catayst



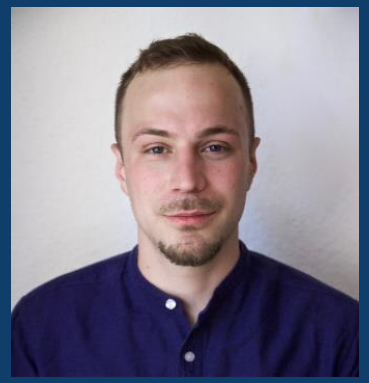


Ionotronics & ion-triggered mesoscopic phenomena

Mesoscopic phenomena in energy conversion materials



THE ONES WHO DID THE WORK…



Moritz L. Weber
chemistry, PhD/PD

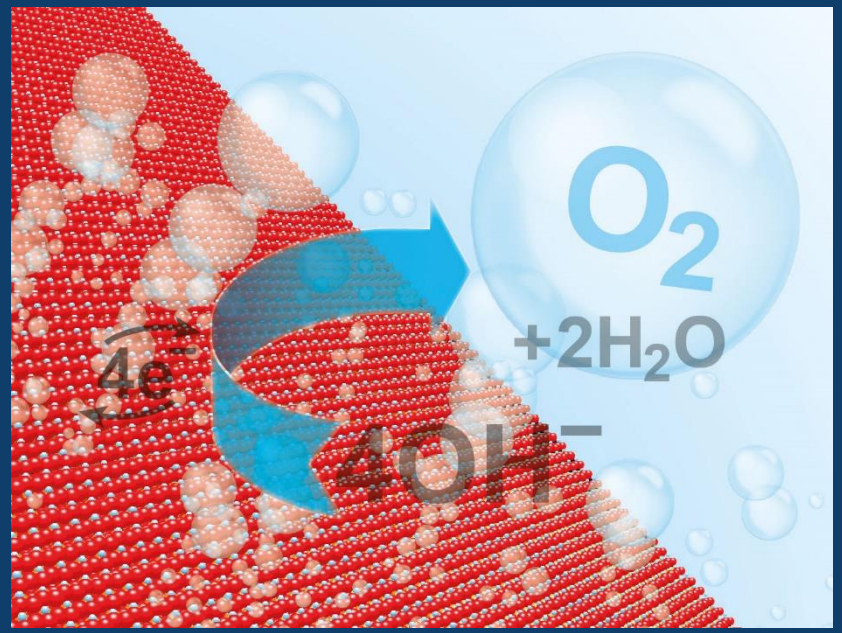
Lisa Heymann
chemistry, PhD student

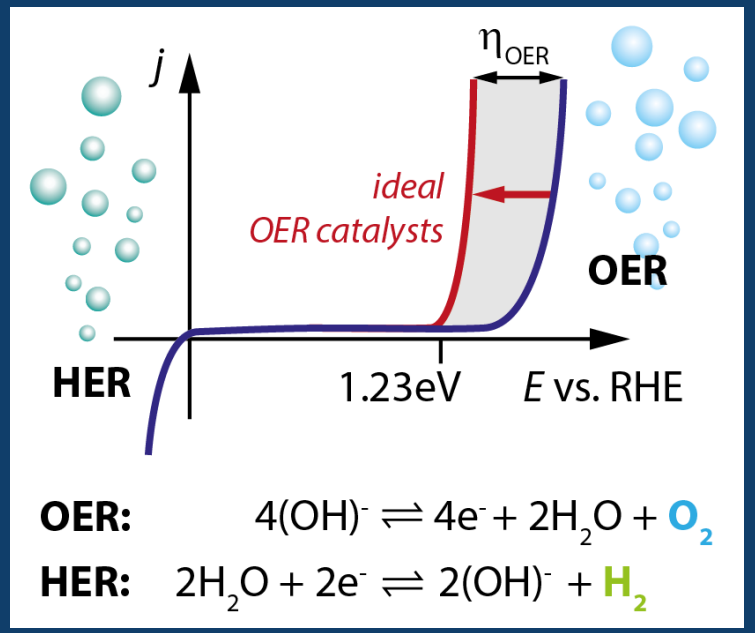
Anton Kaus
chemistry, Master/PhD

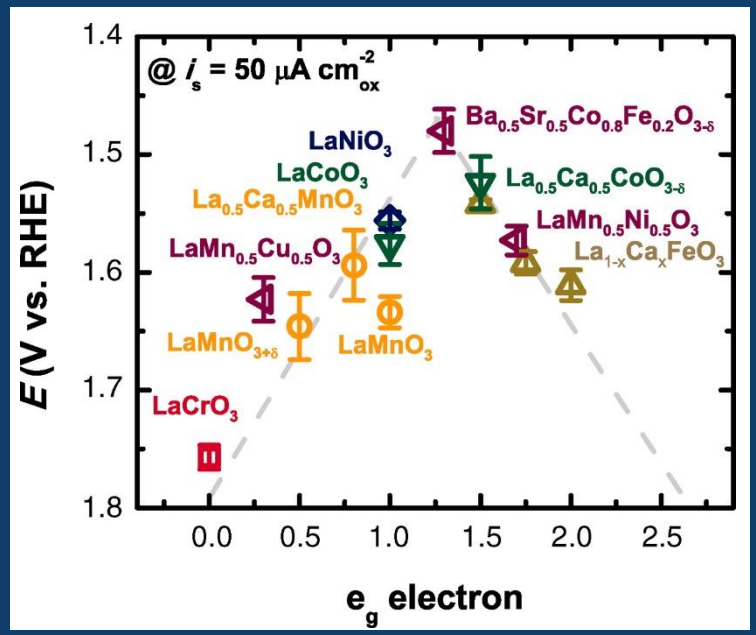
Marc-Andre Rose
physics, PhD/grad. 2022

Suqin He
physics, PhD student

TAILORING INTERFACE CHEMISTRY FOR CATALYTIC REACTIONS





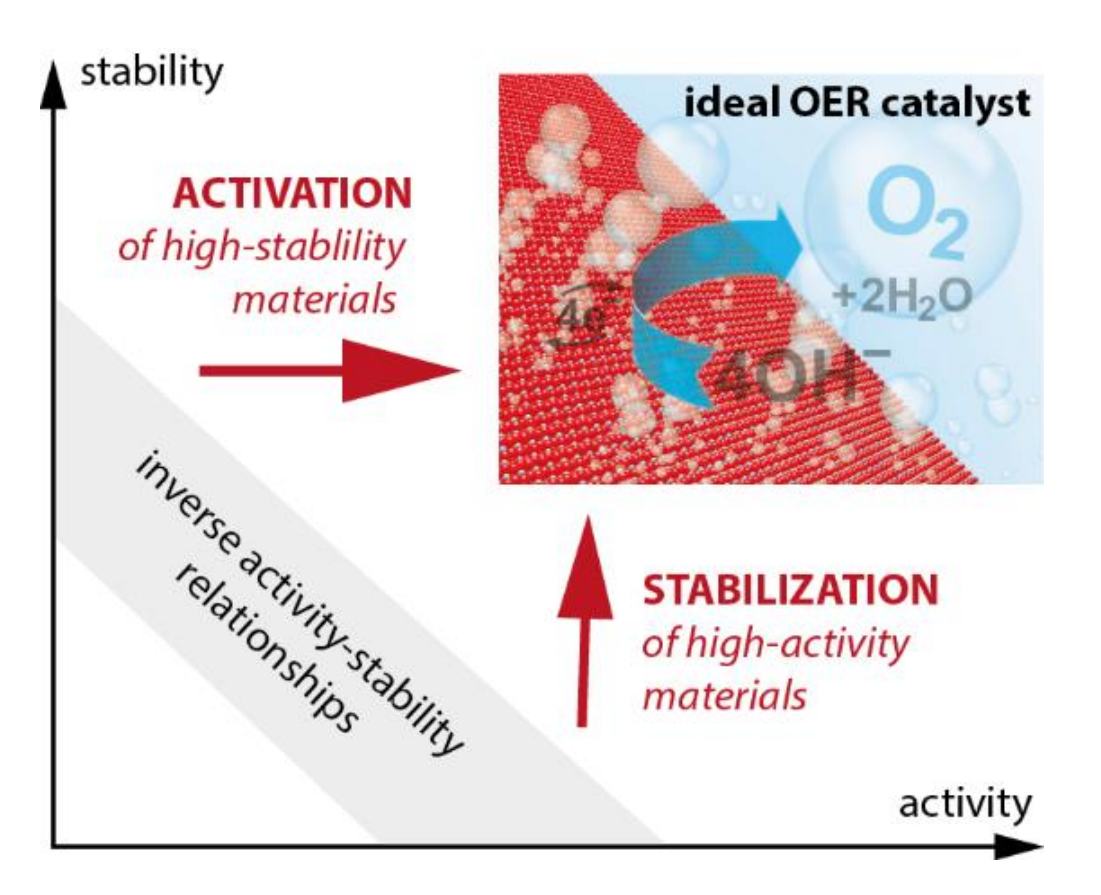


Suntivich, Shao-Horn, Science (2011)

Oxygen evolution reaction (OER) as bottleneck for efficient & economic electrolysis of water

→ Perovskites can avoid noble metals and can perform comparable to CoFe-/NiFe-related benchmarks (NPs, spinels, …)

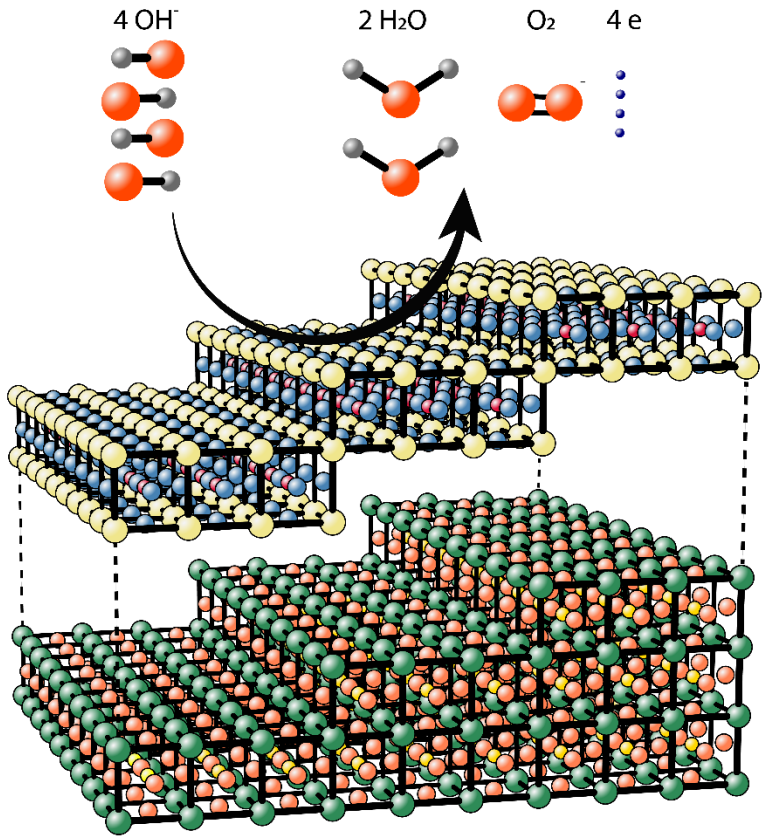
MAJOR OBSTACLES TOWARD EFFICIENT OER CATALYSIS

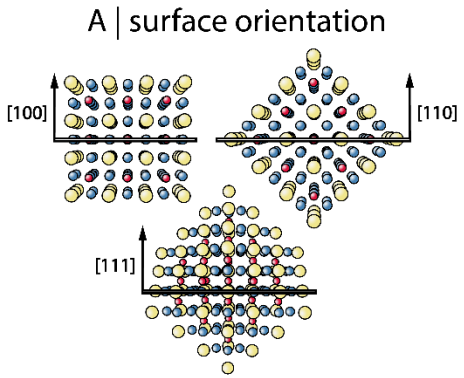


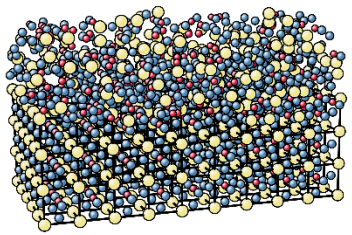
inverse stability-activity relationships

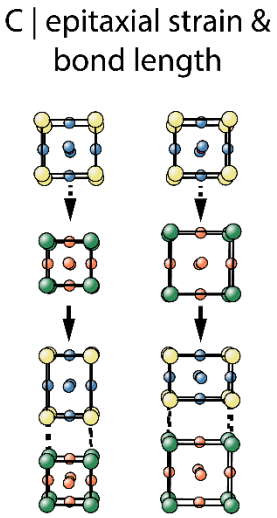
Can we overcome inherent limitation by atomistic understanding and materials design?

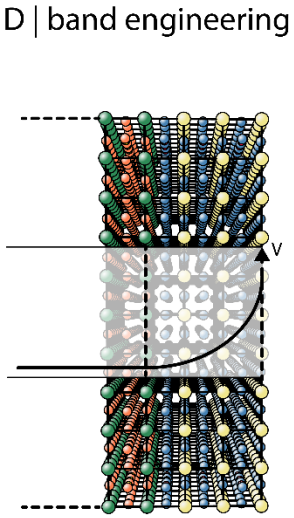
EPITAXIAL OER CATALYSTS – MODEL SYSTEMS AND BEYOND

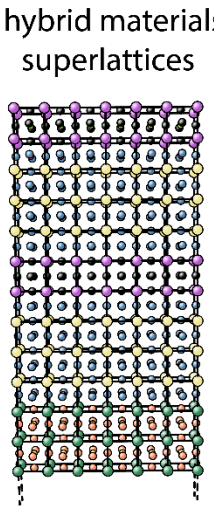






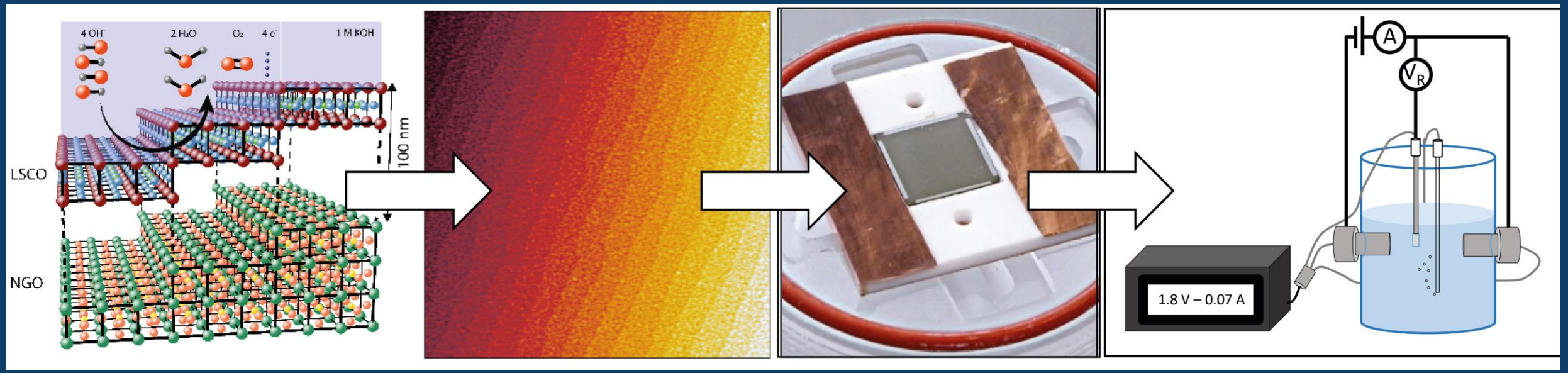


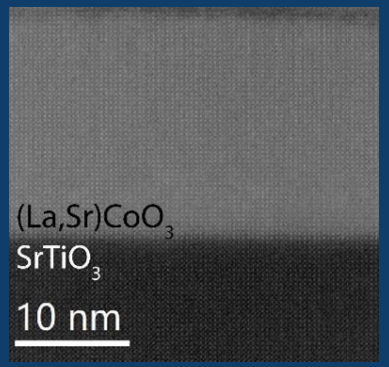


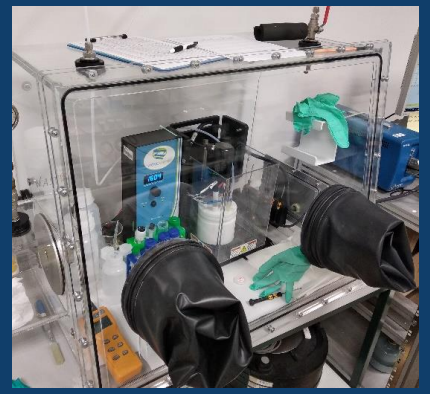


[Weber, Gunkel, J. Phys. Energy (2019)]

WORK FLOW TOWARD OER ANALYSIS

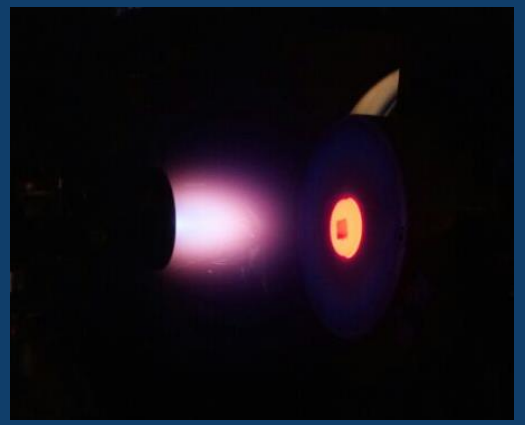


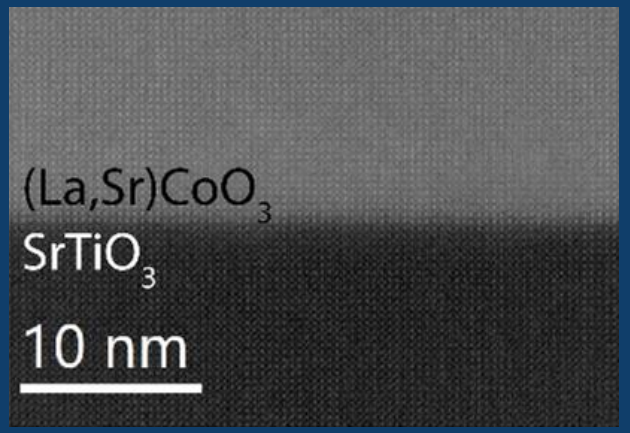


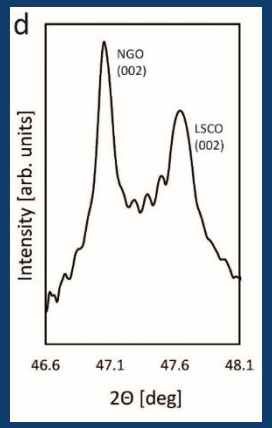


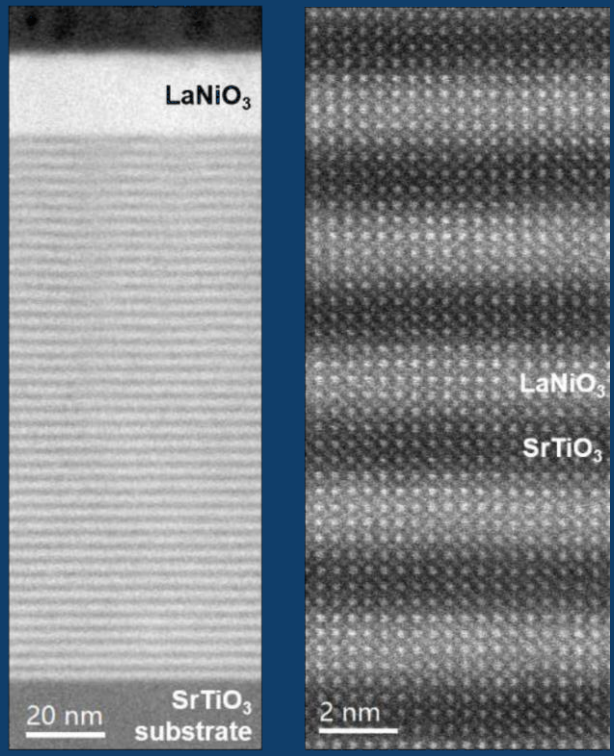
[Weber, **Gunkel**, J. Phys. Energy (2019)]

OXIDE EPITAXY – ATOMICALLY TAILORED OXIDES

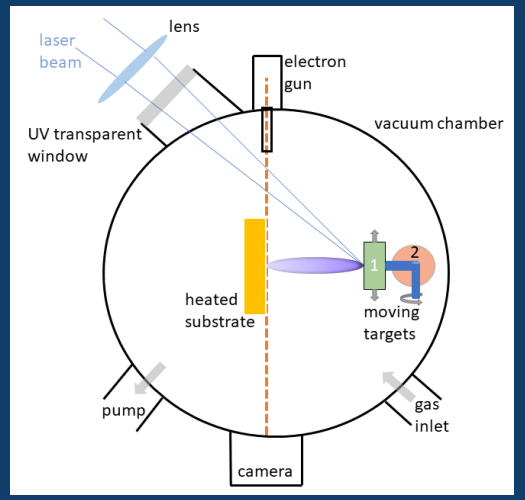




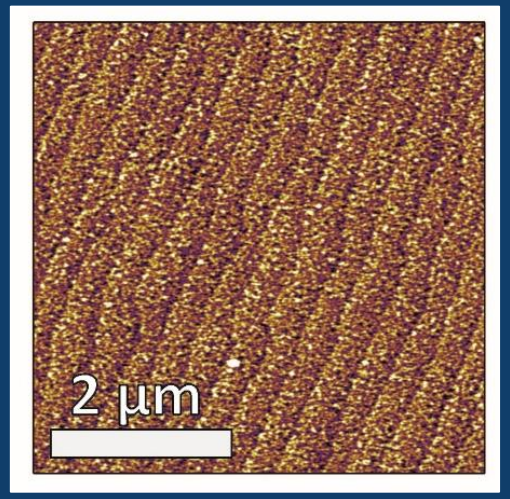


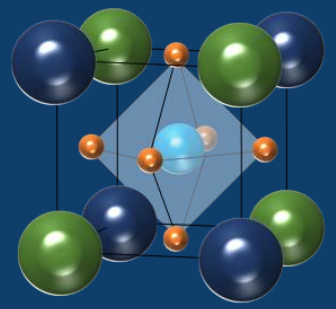


[Bäumer et al., Nature Mater. (2021)]



PLD – *pulsed laser deposition*



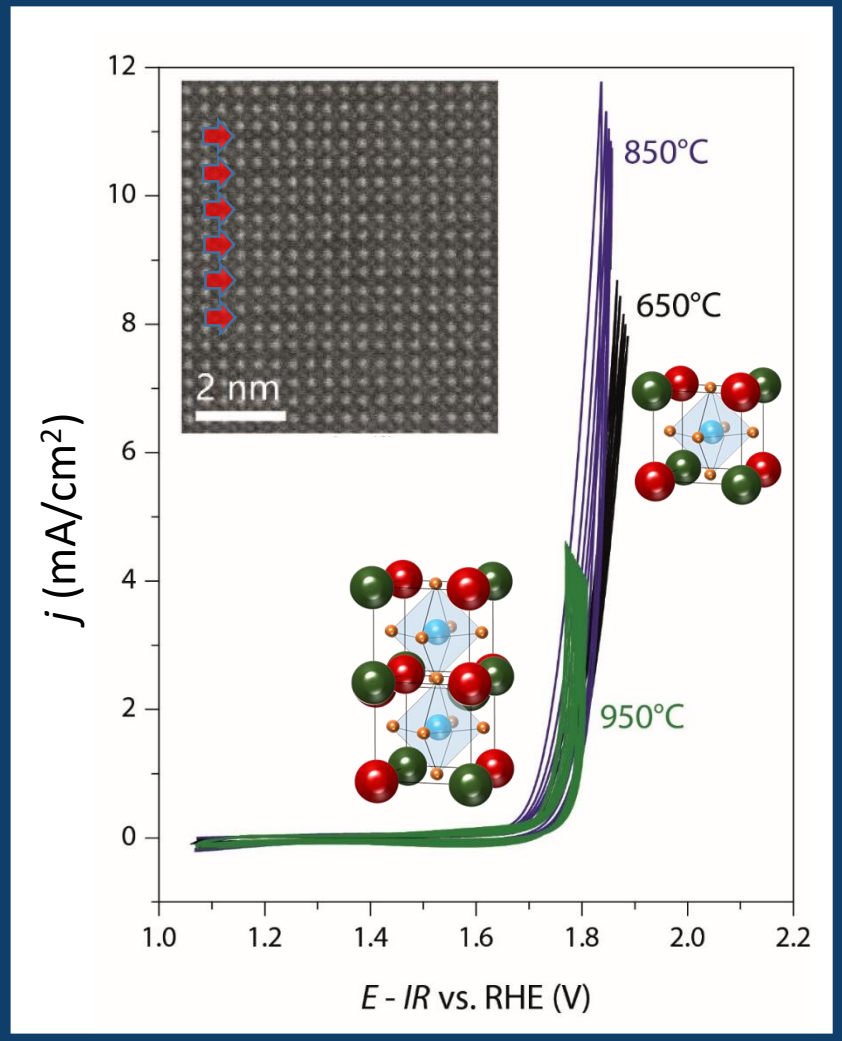


$(La_{0.4},Sr_{0.6})CoO_{3-\delta}$

[Gunkel et al., Appl. Phys. Lett. (2010)] | [**Gunkel** et al., ACS Applied Mater. Inter. (2016)] | [Weber et al., in prep. (2022)]

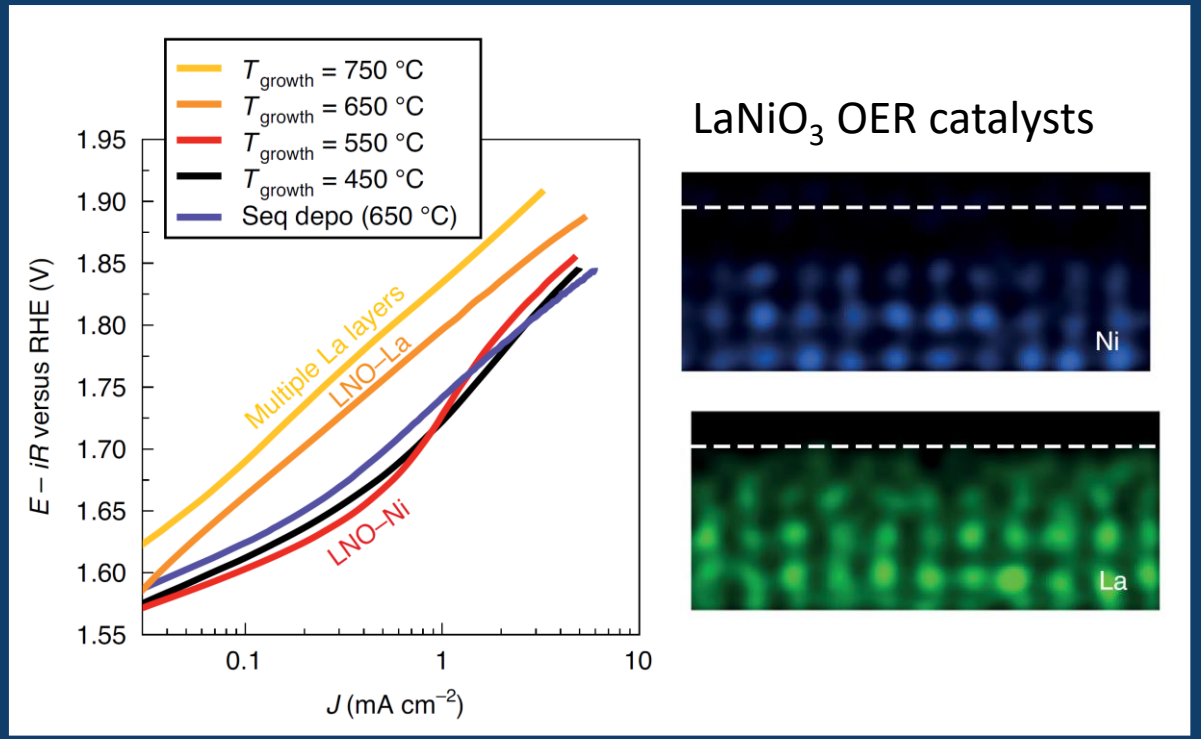
TOWARD ATOMIC CONTROL OF OER CATALYSTS

Oxygen-vacancy ordering vs. activity in PBCO



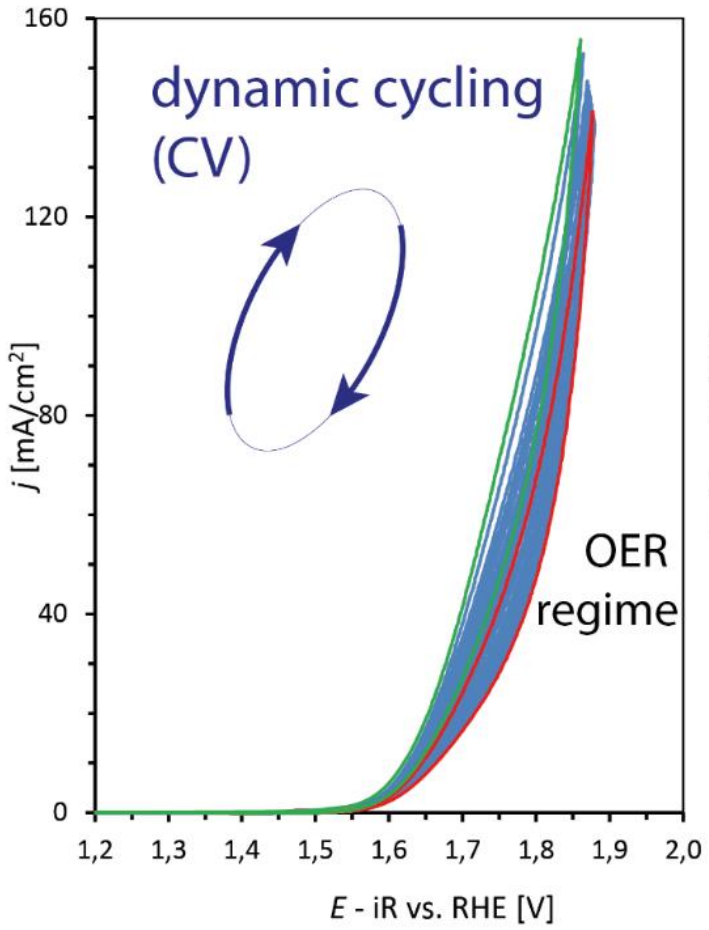
[Gunkel et al., ACS Catalysis (2017)]

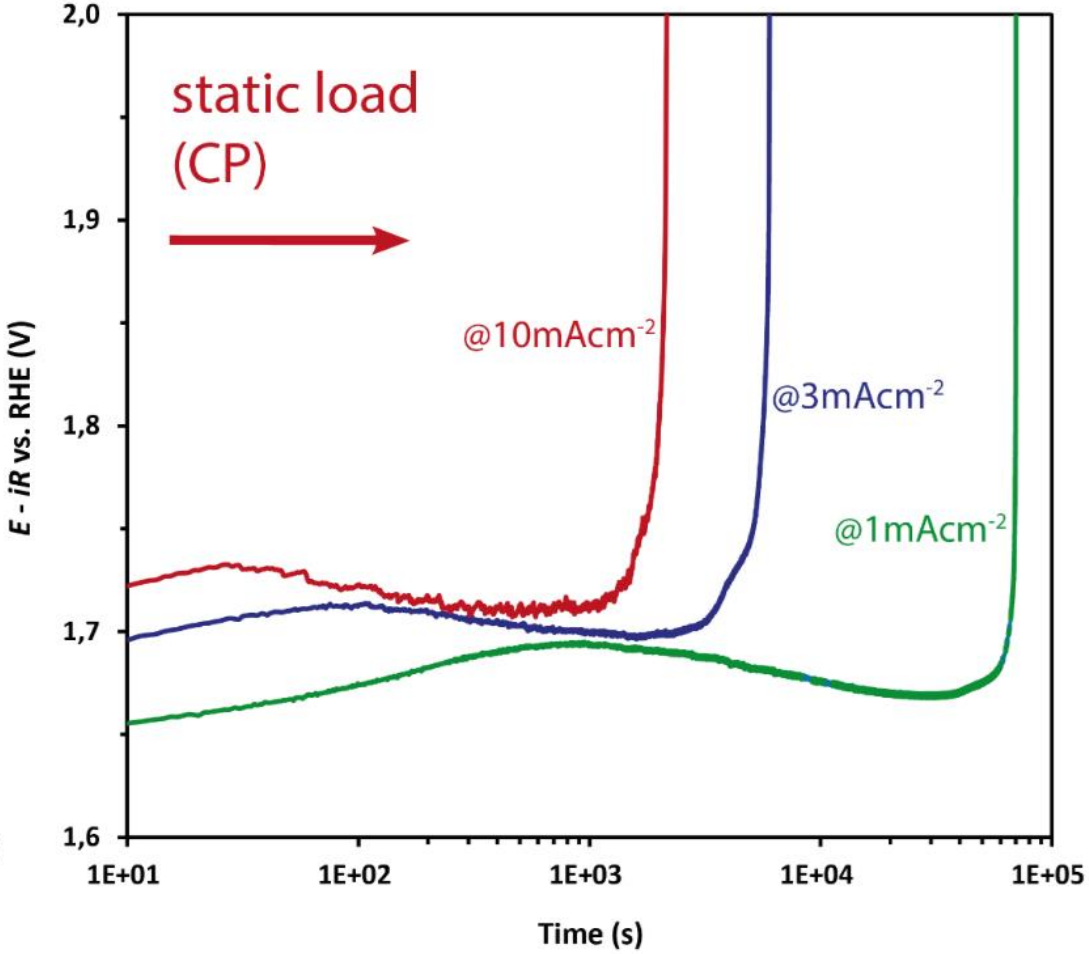
Activity vs. surface termination vs. surface transformation

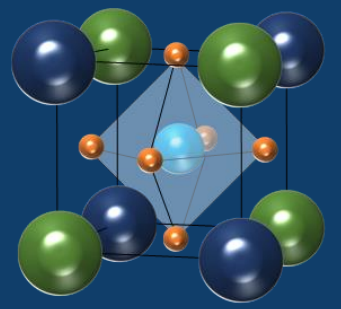


[Bäumer, …, Gunkel, et al., Nature Materials (2021)]

CATALYTIC PERFORMANCE OF EPITAXIAL LSCO





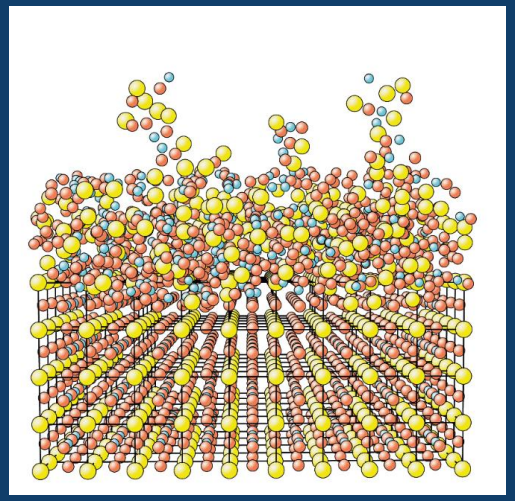


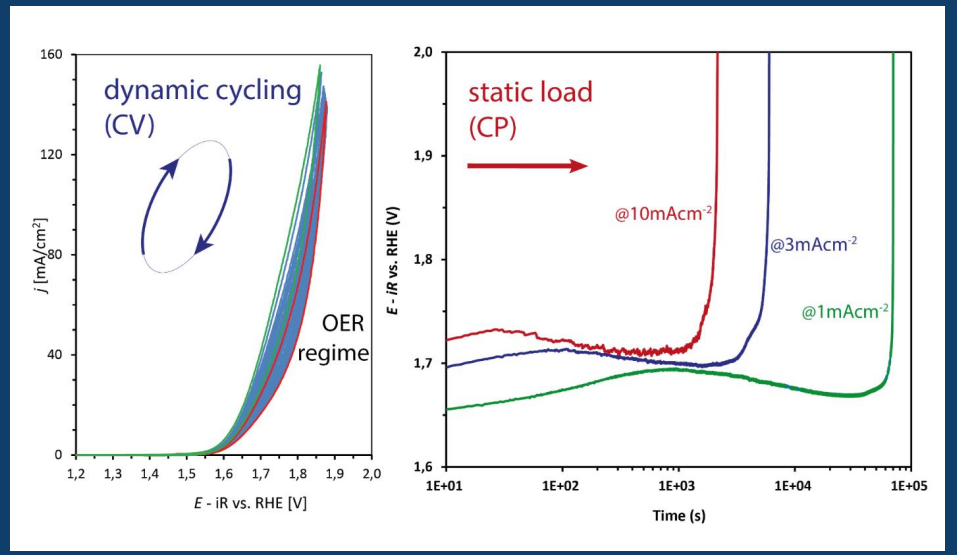
$(La_{0.4},Sr_{0.6})CoO_{3-\delta}$

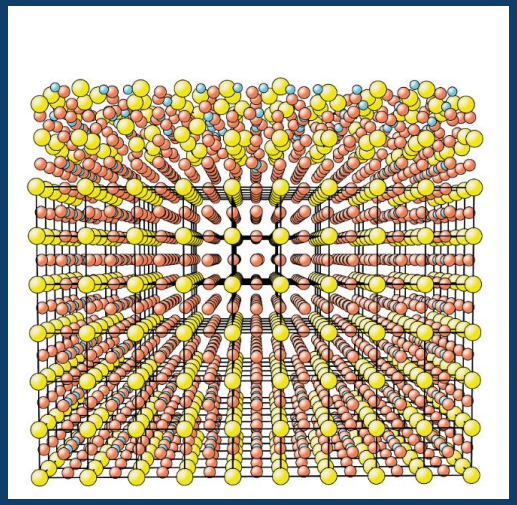
0.1M KOH, 300K

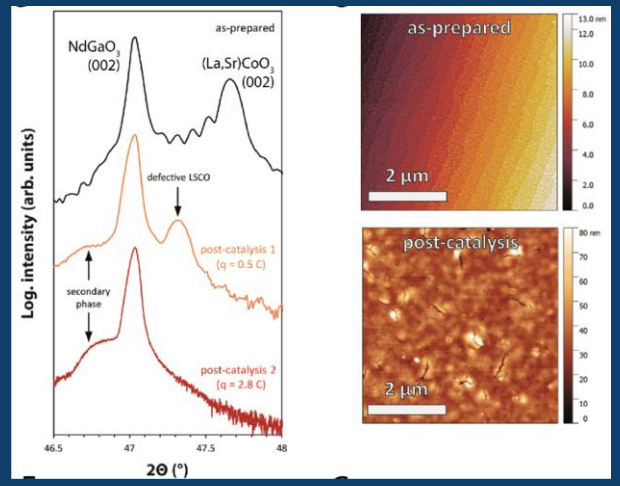
[Weber, … Gunkel, Chem. Mater. (2019)] [Weber et al., to be submitted (Feb 2022)]

DEGRADATION BEHAVIOR OF LSCO

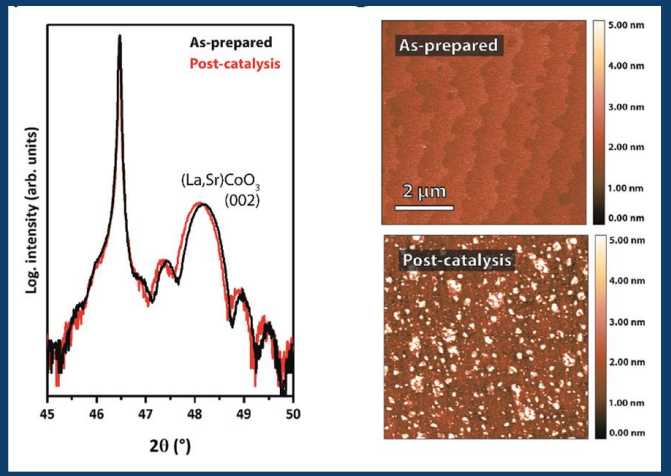






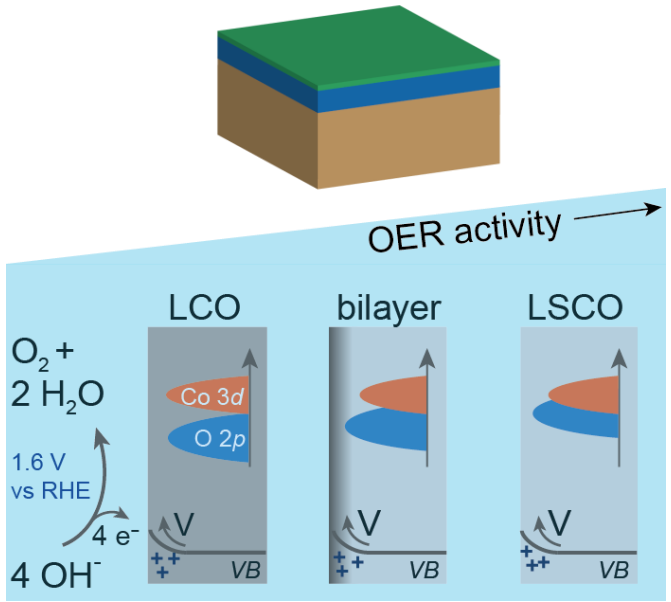


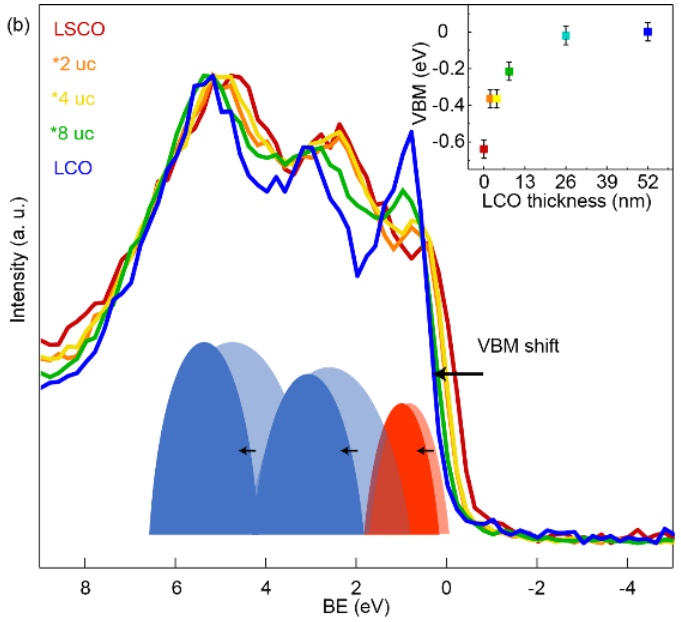
Different degradation behavior
dynamic vs. static load
bulk degradation vs. surface passivation

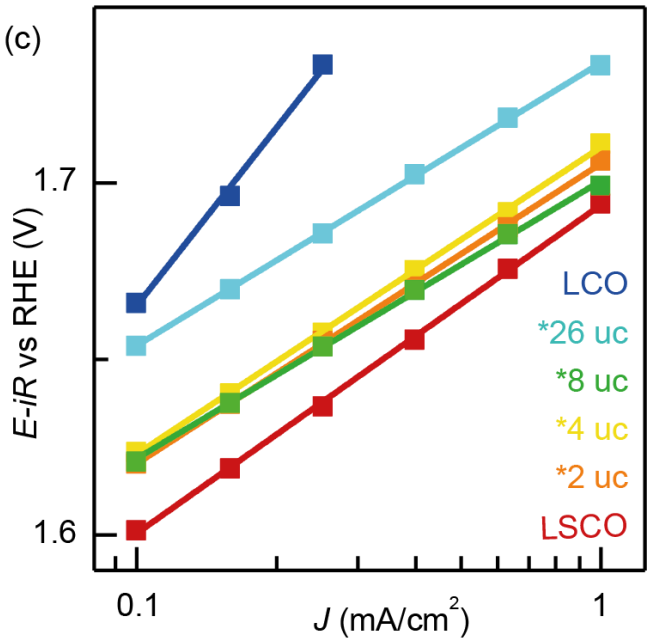


[Weber, … Gunkel, Chem. Mater. (2019)] [Weber et al., to be submitted (March 2022)]

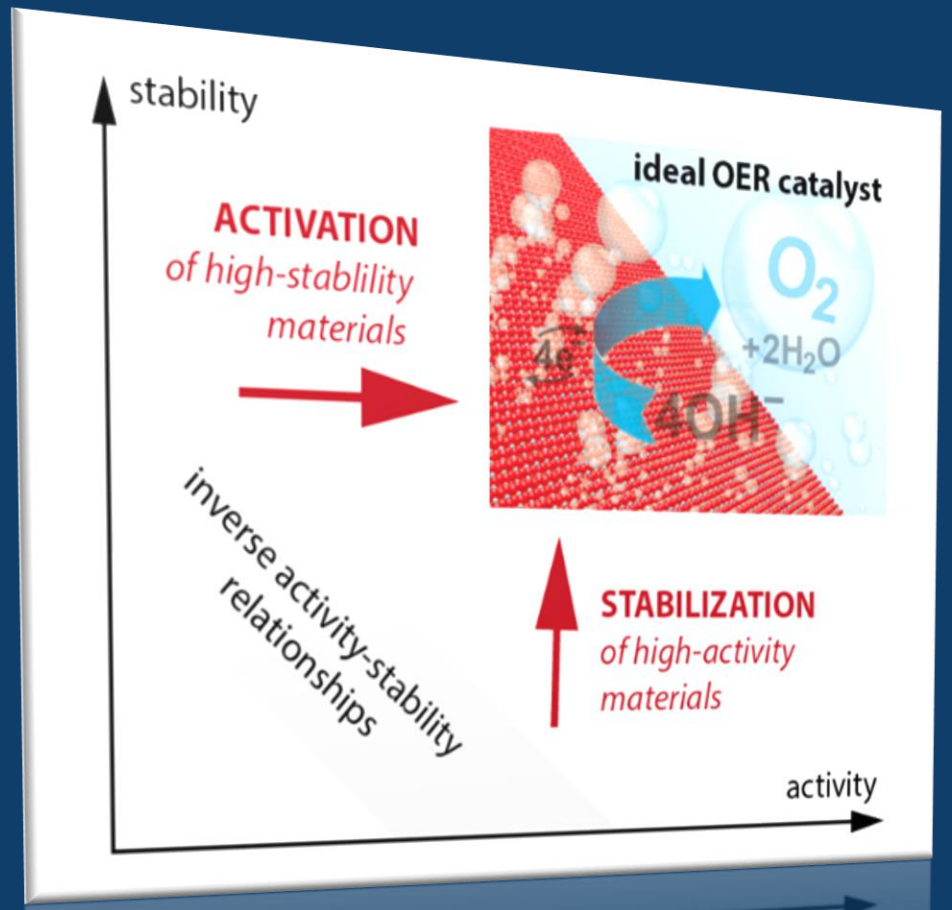
BREAKING INVERSE ACTIVITY-STABILITY DILEMMA AND SCALING RELATIONS BY HYBRID MATERIAL DESIGN

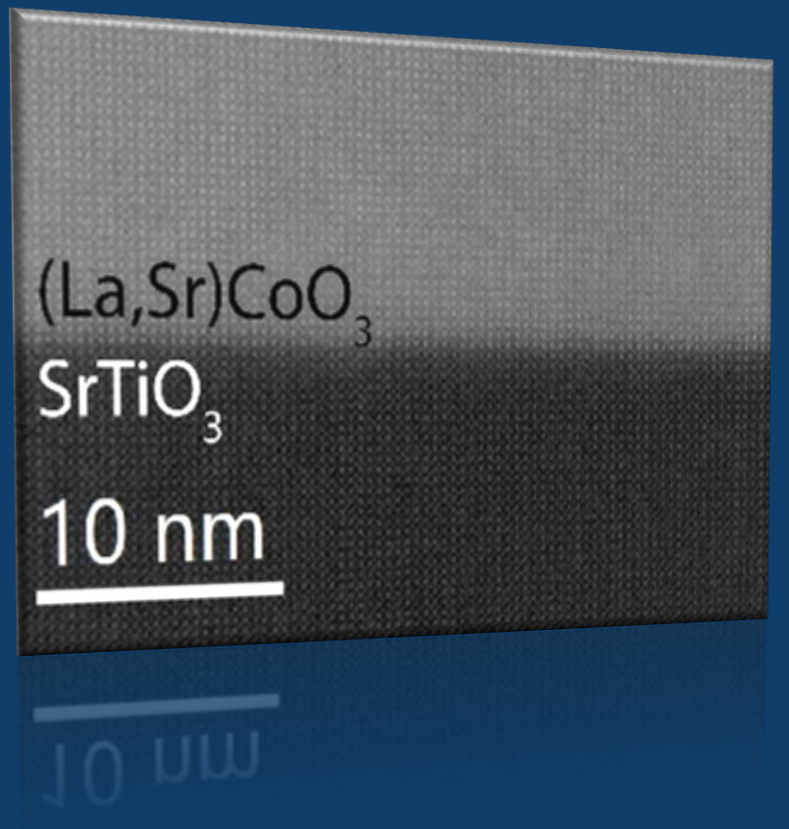






[Heymann, …, Gunkel, ACS Appl. Mater. Interfaces (in proof, 2022)]





Space-charge-mediated phenomena at oxide interfaces – Tailoring interface chemistry for electrochemical water splitting