

Following low and high-temperature electrolysis processes with in-situ and cryo electron microscopy

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Background incl. aims

Electrochemistry plays a crucial role in various hydrogen production technologies [1], yet understanding the intricate nanoscale processes that govern these reactions remains a significant challenge. To address this gap, we employ advanced electron microscopy techniques to visualize and unravel the nanoscale mechanisms behind electrochemical phenomena.

Methods

While the Plasma Focused Ion Beam (PFIB) tomography at room temperature allows us to visualize the evolution of solid oxide fuel cell (SOFC) [2] electrodes due to operation, and the cryo PFIB tomography allows characterizing proton exchange membrane (PEM) [3] of low-temperature water electrolysis. This coupled with the in-situ TEM allows us probing the mechanisms of low and high-temperature electrolysis.

Results

PFIB tomography enables us to generate high-resolution 3D reconstructions of SOFC materials, revealing the evolution of triple-phase boundaries and potential degradation sites that influence ion transport and catalytic activity. In situ TEM experiments, utilizing MEMS chips, allow us to monitor electrochemical processes in real time. By studying Sr_{0.95}Fe_{0.9}Mo_{0.1}O_{3-δ} (SFM) [4] and related materials, we demonstrate exsolution mechanisms that can impact the performance of SOFCs. Further, we showcase the application of MEMS-based chips in visualizing power-to-x processes, exemplified by methane generation on Ni catalysts.

For PEM MEAs, maintaining the original hydration level is crucial to understand degradation mechanisms. Our cryo workflow which includes largescale surface investigation using a laser scanning microscopy (LSM), preserves hydration throughout sample preparation, FIB tomography, TEM lamella preparation, and TEM characterization, ensuring optimal sample preservation for TEM imaging.

Conclusions

Our research highlights the transformative power of electron microscopy in unraveling the nanoscale secrets of hydrogen production. By visualizing these intricate processes, we gain a deeper understanding of the factors influencing material performance and optimize material design to enhance the efficiency and durability of hydrogen production technologies. This approach holds immense promise for advancing the H₂ value chain and driving the transition towards a clean energy future.

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Keywords:

FIB-tomography, in-situ, and cryo TEM

Reference:

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