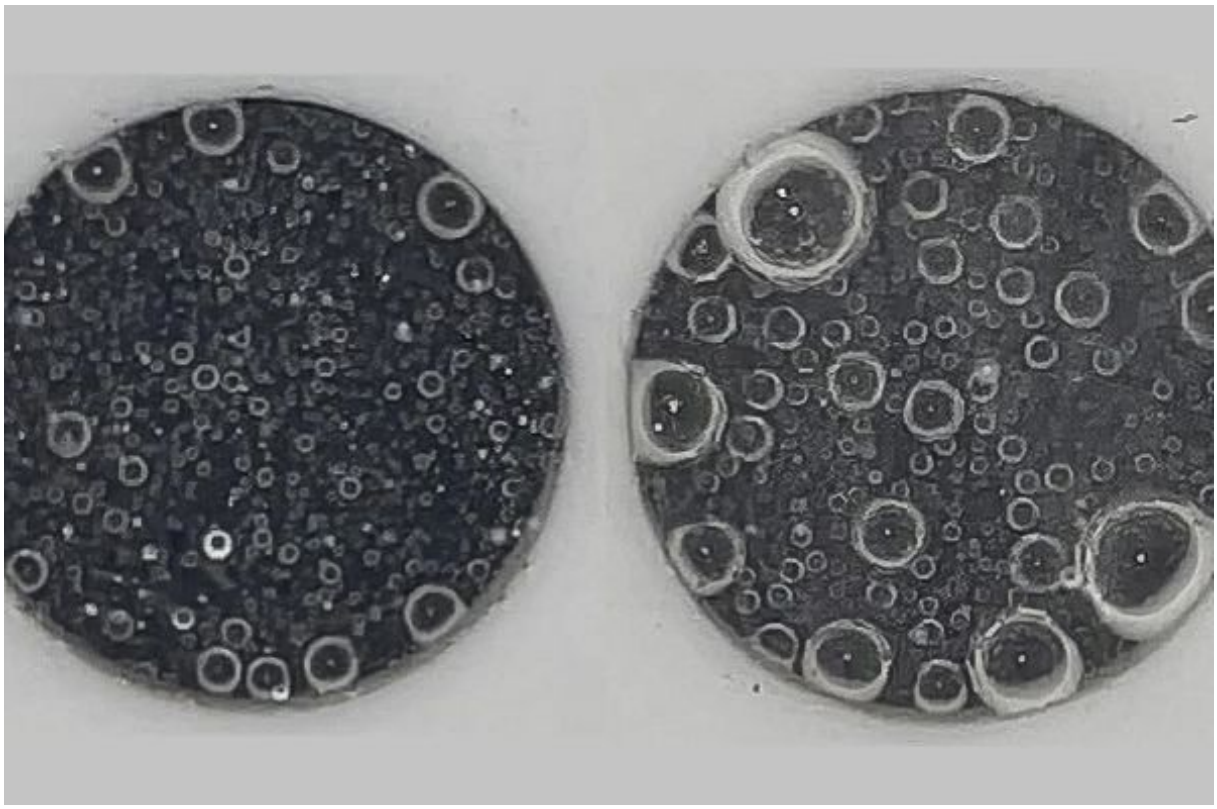


Helping catalysts breathe: Accelerating bubble release improves water electrolysis performance

Water electrolysis transforms water into hydrogen and oxygen gas. Now, ICFO researchers and collaborators have engineered the catalyst interface to tackle oxygen bubble accumulation, improving electrochemical performance. The strategy, published in ACS Catalysis, offers a path toward more efficient green hydrogen generation.

October 22, 2026

Hydrogen, if efficiently produced through water electrolysis, could become a major clean energy carrier for decarbonizing our society. One often overlooked challenge in water electrolysis, though, is the formation of oxygen bubbles at the anode, particularly under acidic conditions and at high current densities. Bubble build up blocks active sites, restricting water access to the catalyst surface and, consequently, degrading overall performance.

ICFO researchers, **Aparna Das**, **Dr. Viktoria Golovanova**, **Dr. Anku Guha**, **Adrian Pinilla Sanchez**, **Tengyu Chen**, **Dr. Lu Xia**, **Ranit Ram**, **Andrea Rogolino**, **Dr. Kaiwen Wang**, led by **Prof. F. Pelayo Garcia de Arquer** **at ICFO**, have now developed a strategy that mitigates the problems associated with bubble accumulation. By engineering oxygen vacancies (a spot in the material where an oxygen atom is missing), interfacial water is better adsorbed at the catalyst surface. This promotes oxygen bubble detachment and suppresses the instabilities these bubbles induce, thereby improving electrochemical performance. The study, recently published in ACS Catalysis, was conducted in close collaboration with Prof. Jordi Arbiol at the Catalan Institute of Nanoscience and Nanotechnology (ICN2) and Prof. Nuria Lopez at the Institute of Chemical Research of Catalonia (ICIQ), as well as the University of Bayreuth and ALBA Synchrotron Light Source.

To achieve these results, the team engineered a ruthenium oxide-cerium oxide (RuOx-CeOx) catalyst as the anode in a water electrolyzer . Compared with a RuOx control catalyst, the bubbles that formed were four times smaller and the operating voltage was lower, which translates into energy savings. This is because CeOx acts as an oxygen buffer at the catalyst surface: it promotes the formation of oxygen vacancies, increases water availability and accumulation, and speeds up bubble detachment. i¿½Although oxygen-vacancy formation s commonly regarded as a source of instability in ruthenium oxides, our results show that t can also be beneficial in terms of providing adequate water to the interface at hi h currents,i¿½ explains Aparna Das, first author of the arti le. The team also observed improved performance when using iridium oxide-cerium oxide (IrO -CeOx) systems, suggesting that the strategy could be extended to other catalysts combined with cerium oxide, a generalization the team plans to explore in the coming years.

Overall, this work highlights the importance of considering interconnected phenomena in electrocatalysis and underscores how fundamental surface properties can shape macroscale performance metrics. i¿½By revealing a strong correlation between oxygen vacancies, wat r coverage, bubble dynamics, and catalytic activity, we offer a promising strategy f r engineering more efficient catalyst-electrolyte interfaces,i¿½ says Prof. Pelayo Garci de Arquer, who led the study. i¿½This, we believe, will be essential if we want to produce green hydrogen through water electrolysis under industrially relevant conditio

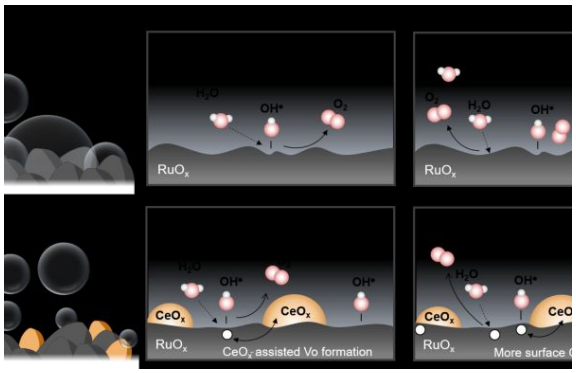
Reference:

Aparna M. Das, et. al.; Oxygen Management in Ruthenium-Cerium Anode Facilitates Water Adsorption and Bubble Desorption for Oxygen Evolution at High Current Densities. ACS Catal. 2026; https://doi.org/10.1021/acscatal.6c04063

Acknowledgements:

ICFO thanks the Fundacio Cellex, Fundacio Mir-Puig, CEX2024-001490-S, the European Union (NASCENT, 101077243), PID2022-138127NA-I00, and RED2024-154266-T projects

funded by the MCIN/AEI/10.13039/501100011033/FEDER, UE; the European Union (NASCENT, 101077243) and ICONIC (101115204); Ignite (7th edition), Generalitat de Catalunya through CERCA (SGR 2021 01455); Fundacion Ramon Areces (CIVP21S13318). ICN2 thanks the Generalitat de Catalunya 2021SGR00457; the Advanced Materials programme supported by MCIN and Next Generation EU (PRTR-C17.I1) and the Generalitat de Catalunya (In-CAEM Project); AMaDE (PID2023-149158OB-C43), funded by MCIN/AEI/10.13039/501100011033/ and by i¿½ERDF A way of making Europei¿½, by the i¿½European Unioni¿½; the Seve o Ochoa program from Spanish MCIN/AEI (Grant No.: CEX2021-001214-S); t e CERCA Programme/Generalitat de Catalunya. Part of the present work has been performe in the framework of the Universitat Autonoma de Barcelona Materials Science PhD program D.L.R. acknowledges grant PRE2022-102638. A.G.M. has received funding fr m Grant RYC2021-033479-I, funded by MCIN/AEI/10.13039/501100011033, and by the uropean Union Next Generation EU/PRTR. The authors acknowledge the use of instrumentation as well as the technical advice provided by the Joint Electron Microscopy Center at ALBA JEMCA). ICN2 further acknowledges funding from Grant IU16-014206 (METCAM-FIB) funde by the European Union through the European Regional Development Fund (ERDF), with the support of the Ministry of Research and Universities, Generalitat de Catalunya. ICN2 is a ounding member of e-DREAM. (60) The authors also acknowledge the Federal Ministry of E ucation and Research (BMBF) under the funding codes Live XAS (Grant 05K22WC1) an HighHy (Grant 03SF0689B). The authors thank Bessy (Berlin, Germany) and DESY (amburg, Germany), members of the Helmholtz Association HGF, for the provision of expe imental facilities. Parts of this research were carried out at the BAMline (Bessy) and PETRA III (DESY). The authors would like to thank Dr. Ana G. Buzanich (Bessy) and Dr. Wolfgang Calieb (DESY) for assistance during the experiments. Beamtime was allocated for proposals 232 12335ST (Bessy) and I-20230896 (DESY). ICFO, ICIQ, and ICN2 acknowledge support from Gen ralitat de Catalunya and AGAUR (2023 CLIMA 00105). L.L., J.M.-V, and N.L. thank the Spanish Ministry of Science and Innovation (PID2024-157556OB-I00 f nded by MICIU/AEI/10.13039/501100011033/ FEDER, UE), and Severo Ochoa Excellence Accre itation (CEX2024-001469-S funded by MCIU/AEI/10.13039/501100011033). L.L. also ackn wledges funding from the European Union's Horizon Europe research and innovation p ogramme through the Marie Sk?odowska-Curie Actions (MSCA) grant (101149049-ADAMox). e thank the Barcelona Supercomputing Center MareNostrum (BSC-RES) for providing enerous computiational resources.



Illustrations comparing oxygen bubble dynamics during the oxygen evolution reaction (OER) on RuOx and RuOx-CeOx catalysts and revealing macroscale differences. Source: ACS Catalysis.