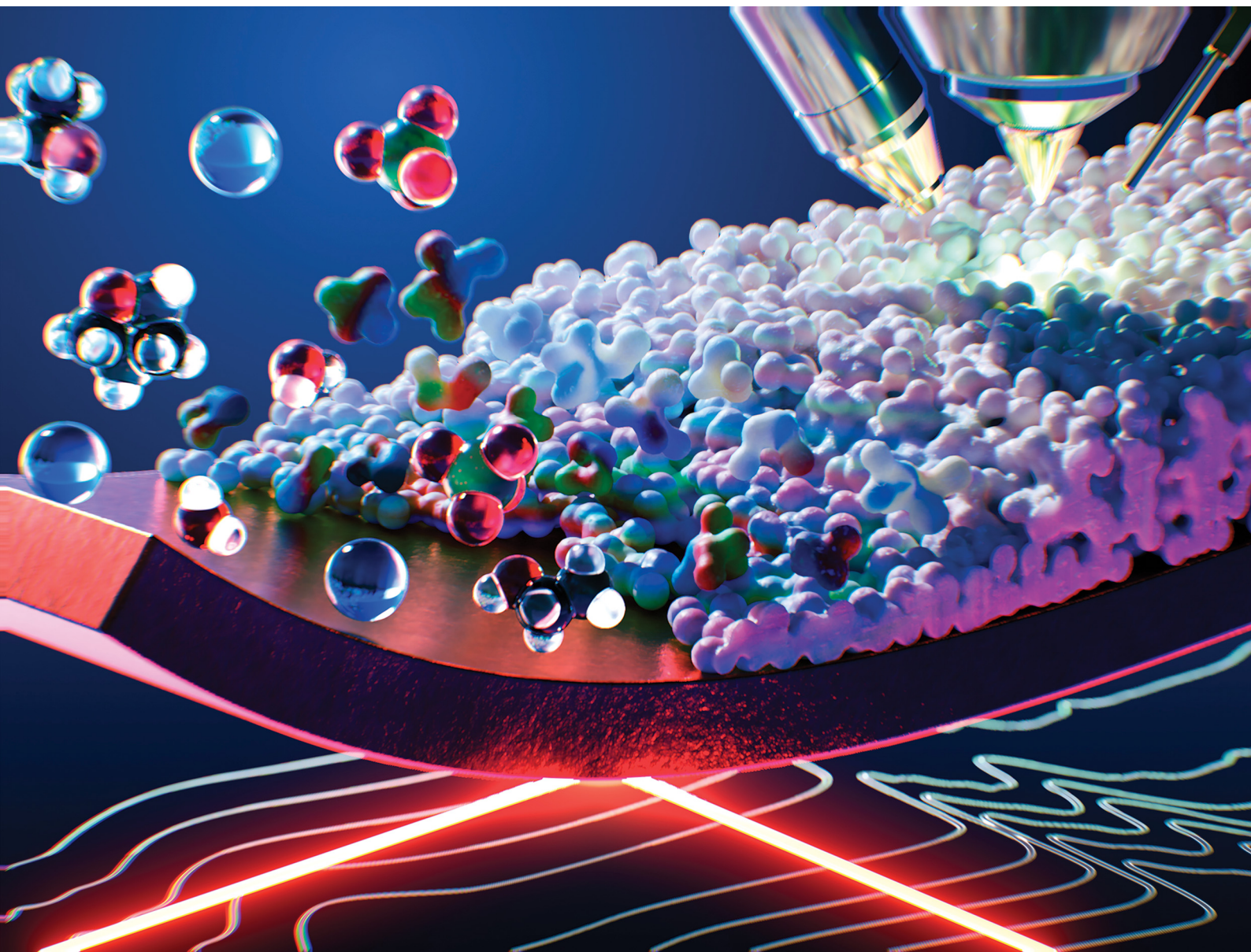


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A self-healing non-precious metal oxide anode in proton exchange membrane electrolysis beyond 1000 h stability at 2 A cm⁻²

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The development of non-precious metal-based anode electrocatalysts is a crucial step towards the large-scale deployment of proton exchange membrane water electrolysis (PEMWE). However, the significant dissolution of non-precious metal materials poses a substantial challenge to their application in PEMWE. In this study, we introduce a dynamically stable anode material consisting of lanthanum-doped cobalt manganese oxide that operates under ampere-level current densities. This anode material exhibits bulk structural stability and maintains a dynamic equilibrium of active sites on its surface. The anode demonstrates sustained performance for over 200 hours at 5 amperes per square centimeter and 1200 hours at 2 amperes per square centimeter in PEMWE. Experimental and computational analyses confirm that the re-deposition of active species at the working potential is responsible for achieving dynamic stability at ampere-level current densities. This innovative concept of a dynamically stable electrocatalyst expands the potential of non-precious metal oxide anodes in PEMWE, reducing reliance on the limited supply of iridium without compromising hydrogen production rates.

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Broader context

The development of non-precious metal anodic electrocatalysts is crucial for the widespread application of proton exchange membrane water electrolysis (PEMWE); however, the significant dissolution of materials poses challenges. In this study, we have for the first time achieved the dissolution and redeposition of non-precious metal catalysts under PEMWE conditions, allowing the catalysts to maintain structural stability at ampere-level current densities and to establish a dynamic equilibrium of active sites on the catalyst surface. Consequently, PEMWE can operate stably for over 200 hours at 5 A cm⁻² and for 1200 hours at 2 A cm⁻².

Introduction

Proton exchange membrane water electrolysis (PEMWE) is a cornerstone technology for green hydrogen production, attributed to its high current density, system simplicity, and inherent safety features, making it a critical enabler for sustainable energy transition and carbon neutrality initiatives.^{1–8} Despite these advantages, iridium (Ir)-based materials remain the only commercially viable oxygen evolution reaction (OER) electrocatalysts offering satisfactory stability and activity in oxidative and acidic environments.^{9–13} However, scaling up the deployment of Ir-based PEMWE (requiring 2 to 4 mg of Ir per square centimeter) would necessitate over 40 years of the current annual Ir production to achieve a 1 TW-scale hydrogen economy.^{13–16} In light of the challenge of scarce Ir-based

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