Strain engineering of Pt-based electrocatalysts for oxygen reaction reduction

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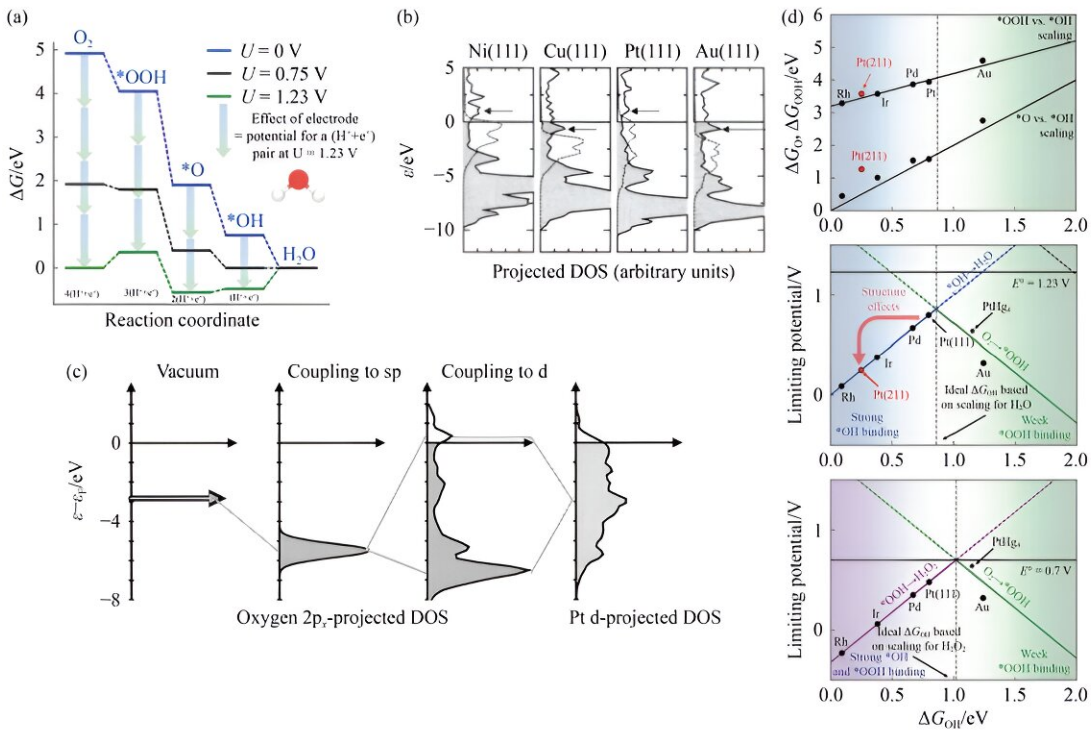

(a) Illustration of free-energy state for four-electron ORR route on Pt(111); (b) schematic diagram of comparison of d-band positions in different metals; (c) schematic diagram of the change of d-band during chemical adsorption of O on Pt(111); (d) comparison of chemical adsorption energy of different metals in ORR steps and free energy relationship between different oxygenated species. DOS represents density of state. Credit: HIGHER EDUCATION PRESS

The quest for efficient and durable oxygen reduction reaction (ORR) electrocatalysts is pivotal for the advancement of proton exchange membrane fuel cell (PEMFC) technology. Despite their widespread use, the high cost and limited availability of Pt have driven the scientific community to explore strategies to improve the catalytic efficiency and durability of Pt-based materials.

Among these, strain engineering has shown promising results by manipulating the electronic structure of catalysts, thus optimizing their catalytic behavior.

A review in *Frontiers in Energy*, authored by a team of researchers led by Xiaogang fu, Yan Zhang, Wanglei Wang, provides a detailed analysis of recent advances in understanding the strain effects on ORR catalysts. It discusses the methodologies for strain engineering of Pt-based catalysts and the challenges and prospects for strain modulation.

The study reveals that surface strain engineering can effectively tune the electronic structures of Pt-based catalysts, leading to improved catalytic performance.

By applying external stresses or through the synthesis of core-shell structures, alloys, and defect-rich materials, researchers can introduce controlled strains that alter the atomic spacing and lattice parameters of the catalysts. This, in turn, affects the distribution of the metal ion electron cloud and its interactions, leading to a precise control of the d-band level position, which is directly linked to the adsorption capacity and management of substance transport rates.

The findings of this review are of paramount importance for the future of sustainable energy systems. By providing a roadmap for the development of more efficient Pt-based electrocatalysts, the research contributes to the reduction of costs associated with PEMFCs.

Furthermore, the insights into strain engineering could potentially extend to other catalytic systems, promoting a broader impact on the field of catalysis.

More information: Zeyu Wang et al, Strain engineering of Pt-based electrocatalysts for oxygen reaction reduction, *Frontiers in Energy* (2024). DOI: 10.1007/s11708-024-0932-x

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