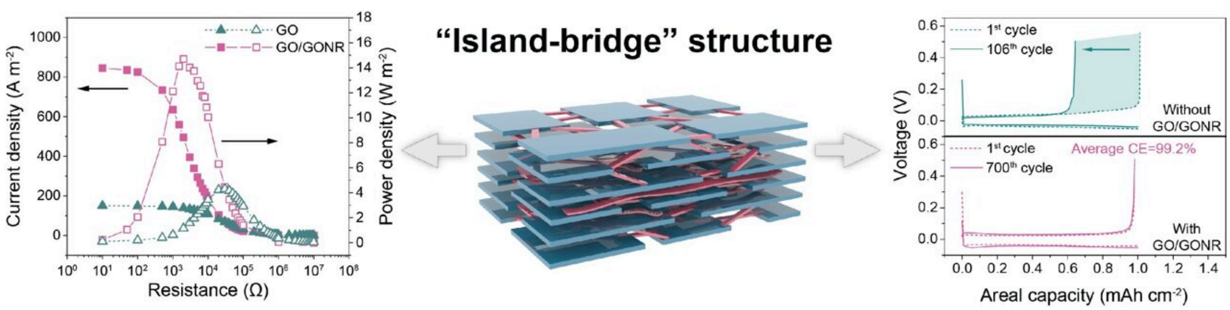
Harnessing blue energy: Advanced nanofluidic membranes boost aquatic energy conversion efficiency

July 25 2024



This image illustrates the innovative 'island-bridge' nanostructure used in nanofluidic membranes, which significantly enhances performance in aqueous energy storage and conversion. On the left, the plots depict the enhanced current density and power density of graphene oxide (GO) with graphene oxide nanoribbons (GONR) compared to GO alone, across varying resistances. The middle graphic demonstrates the layered 'island-bridge' architecture, designed to optimize ion transport. The right graph shows the voltage and capacity performance over multiple cycles, highlighting the stability and efficiency improvements with the addition of GONR. Credit: Energy Materials and Devices, Tsinghua University Press

To achieve carbon neutrality, advancements in energy conversion and storage technologies are essential. Current aqueous energy devices suffer from performance limitations due to the trade-off between permeability and selectivity in permselective membranes. This trade-off hampers the efficiency of energy conversion and storage systems, necessitating the development of membranes that can balance these properties effectively. Due to these challenges, further research is required to explore innovative membrane structures that can enhance the performance of energy conversion and storage devices.

A research team from Tsinghua University has published a study in *Energy Materials and Devices*. They developed a novel "island-bridge" structured nanofluidic membrane to address the critical challenge of balancing permeability and selectivity in energy conversion and storage systems. This innovative membrane design promises to significantly enhance the efficiency of aqueous energy devices, paving the way for more effective and reliable renewable energy solutions.

The study introduces a pioneering "island-bridge" design that self-assembles two-dimensional nanoribbons and nanosheets into nanofluidic membranes. Nanosheets act as isolated islands with high surface charge density, providing superior ionic selectivity. Meanwhile, the bridge-like nanoribbons enhance permeability and water stability due to their low surface charge density and high aspect ratio.

Molecular simulations and experiments demonstrated that these membranes significantly boost the performance of osmotic power generators and zinc metal batteries. Notably, the membranes achieved a power density of 18.1 W/m^2 in osmotic power generation, surpassing the commercial benchmark of 5 W/m^2.

Additionally, the membranes exhibited high Coulombic efficiency and extended lifespan in zinc metal batteries, showcasing their potential in improving energy storage solutions. This design effectively balances permeability and selectivity, addressing a major bottleneck in current energy conversion and storage technologies, and shows promise for scalable applications in enhancing the efficiency and stability of these systems.

Dr. Yu Lei, a leading researcher in the study, emphasized the significance of their findings, "Our innovative island-bridge nanofluidic membranes mark a significant advancement in energy technology. By effectively balancing permeability and selectivity, these membranes not only enhance the efficiency of energy conversion and storage devices but also offer a stable and scalable solution. This breakthrough opens new possibilities for integrating renewable energy sources into the power grid , which is crucial for achieving global carbon neutrality goals."

The successful implementation of these high-performance membranes could revolutionize the field of renewable energy by providing more efficient and reliable energy conversion and storage solutions. These advancements pave the way for enhanced integration of renewable energy sources into the power grid, contributing significantly to global carbon neutrality goals.

More information: Yifu Gao et al, "Island-bridge"-structured nanofluidic membranes for high-performance aqueous energy conversion and storage, *Energy Materials and Devices* (2024). DOI: 10.26599/EMD.2024.9370041

Provided by Tsinghua University Press

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