

# An ultra-high areal loading MnO<sub>2</sub> electrode

Stanford researchers within the Cui Lab have discovered a promising practical application for grid-scale energy storage by solving poor electronic conductivity in Mn based aqueous batteries, resulting in cycling with an **ultrahigh areal loading of 20 mAh cm<sup>-2</sup> for over 200 cycles with only 13% capacity loss.**

Poor electronic conductivity of electro-deposited MnO<sub>2</sub> is a key critical problem that limits the maximum specific areal loading, producing only a thin layer of MnO<sub>2</sub> with low areal loading (around 0.005~0.05 mAh cm<sup>-2</sup>) during the charge/discharge cycle. Stanford researchers discovered, by tuning the temperature, the deposited phase of MnO<sub>2</sub> can be manipulated from  $\gamma$ -MnO<sub>2</sub> with low conductivity to  $\alpha$ -MnO<sub>2</sub> with 2 orders of magnitude increase in conductivity.

## Stage of Development

- Proof-of-Concept

## Applications

- Potential use for manganese-hydrogen and manganese-zinc aqueous batteries in **grid-scale energy storage**

## Advantages

- **More efficient:**
  - Can be cycled with 20 mAh cm<sup>-2</sup> for over 200 cycles with only 13% capacity loss
  - Increase in electronic conductivity of electro-deposited MnO<sub>2</sub> **by 2-3 orders of magnitudes** compared to conventional Mn<sup>2+</sup>/MnO<sub>2</sub> electrode (from 0.005~0.05 mAh cm<sup>-2</sup> to 33 mAh cm<sup>-2</sup>)

- Increase in electronic conductivity **by 100~1000 folds** compared to other doping methods to modify  $\text{MnO}_2$  materials, and temperature dependent tuning technique maintains its polymorph during cycling

- **Scalable**
- **Lower overall cost** for manganese-based batteries
- **Safer** than fire-risk lithium-ion batteries

## Publications

- Xiao, X., Zhang, Z., Wu, Y., Xu, J., Gao, X., Xu, R., ... & Cui, Y. (2023). [Ultrahigh?loading Manganese?based Electrode for Aqueous Battery via Polymorph Tuning.](#) *Advanced Materials*, 2211555.

## Patents

- Published Application: [WO2024211560](#)

## Innovators

- Xin Xiao
- Yi Cui
- Zewen Zhang

## Licensing Contact

### Jon Gortat

Licensing & Strategic Alliances Director for Physical Science

[Email](#)