Energy Materials Network
U.S. Department of Energy

HydroGEN
Advanced Water Splitting Materials

Gallium Nitride (GaN) Protected Tandem Photoelectrodes for High Efficiency, Low cost, and Stable Solar Water Splitting

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NREL Transforming ENERGY
BERKELEY LAB Bringing Science Solutions to the World
Sandia National Laboratories
INL Idaho National Laboratory
Lawrence Livermore National Laboratory

Project Overview

Project Partners

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Pallab Bhattacharya, University of Michigan

Project Vision

Utilizing industry standard GaN material to protect perovskite and III-V photoelectrodes to achieve both high efficiency and long-term stability for sustainable hydrogen production

Project Impact

Clean Hydrogen Production: Enable large-scale production of hydrogen fuel

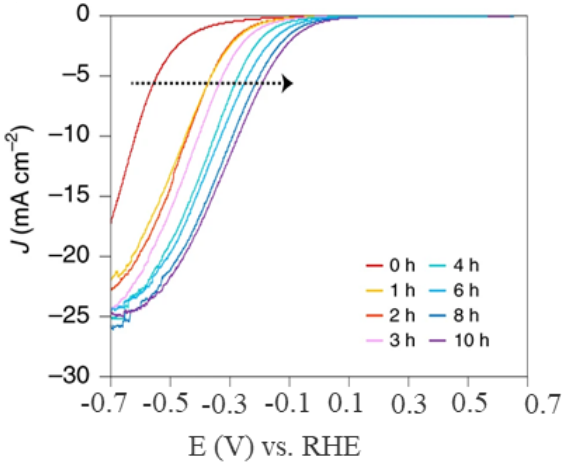
Energy Storage: Facilitate the storage of excess renewable energy by converting it into hydrogen

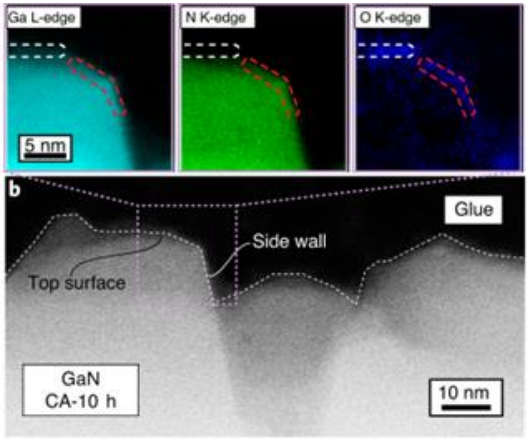
Industrial Applications: Provide a clean source of hydrogen for industrial processes

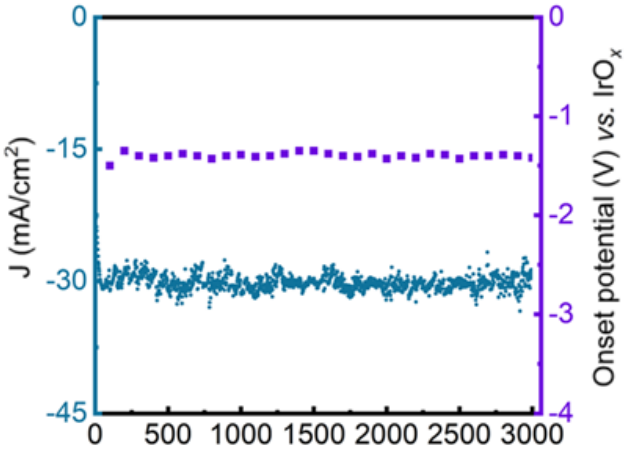
Project Overview

Preliminary result supporting this project

Through collaborations with LBNL and LLNL, we have discovered that GaN surface can be transformed to atomically thin GaON, enabling efficient and stable solar water splitting.







Performance improvement, instead of degradation, due to the formation of atomically thin GaON.

Nature Mater. 2021, 20, 1130; Nature Commun. 2023, 14, 2047.

Project Goal

- **Budget Period 1: Demonstrate GaN-protected double junction tandem device**
  - Milestone 1: GaN-protected tandem device with STH >10% and T80 lifetime for > 100 h.
  - Milestone 2: GaN-protected GaInP/GaInAs photoelectrode with with photocurrent density >12.5 mA/cm^2, OCP >1.5 V, and T80 lifetime stability >100 h

- **Budget Period 2: Improved efficiency and stability of GaN-protected tandem photoelectrode**
  - GaN-protected perovskite and GaInP/GaInAs device with STH >15% and T80 lifetime stability >200 h

Project Goal

- **Budget Period 3: Improved efficiency and stability of GaN-protected tandem photoelectrodes and large-scale testing**
  - GaN-protected perovskite and GaInP/InGaAs photoelectrodes with STH of >20% and T80 lifetime for > 500 h.

- **End of project Goal:** Establish a GaN-protected PEC water splitting system to achieve both high efficiency and long-term stability and demonstrate hydrogen production at a rate of 0.1 g/h for diurnal operation for two weeks.

Approach Summary

- **Achieve efficient solar conversion:**
  - ➢ Perovskite: Spray coating, blade-coating and atomic layer deposition
  - ➢ III-V: MOCVD, and inverted metamorphic growth technique

- **Achieve long-term stability:**
  - ➢ N-terminal GaN nanostructures deposited by low-temperature MBE will be used to prevent photocorrosion and oxidation

- **Solar tracking system will be used for larger-scale practical application with concentrated sunlight**

Highlight Intended Lab Node Collaborations

- Preparation of high-quality perovskites/Si tandem device will be collaborated with Dr. Kai Zhu and Dr. Joseph Berry at NREL.
- Synthesis of GaN-protected GaInP/GaInAs tandem photoelectrodes will be collaborated with Dr. Myles Steiner at NREL.
- PEC characterization and benchmarking will be collaborated with Dr. Todd Deutsch at NREL.
- Electrochemical interface and in-situ characterization will be collaborated with Dr. Joel Ager at LBNL.
- Ab-initio modeling and computational materials diagnostics will be collaborated with Dr. Tadashi Ogitsu at LLNL.

Thanks for listening!