Photoelectrochemical Hydrogen Evolution from Water Vapor for 1000 Hours at 14% Efficiency

Abstract:
The development of a fully-integrated, photoelectrochemical (PEC) device coupling water oxidation to hydrogen evolution using a III-V triple-junction photovoltaic (PV) embedded in a Nafion membrane is reported. This architecture is genuinely monolithic, with wireless catalyst integration being achieved via compression of metal sputter-coated, carbon electrodes against the front and back PV contacts. The resulting MEA-type, sandwich structure minimizes the path length for proton conduction through the membrane ionomer, while simultaneously preventing PV light attenuation by the catalyst layer; a common issue for monolithic PEC structures. Solar illumination of this construct, when operating with a water vapor feed, yields a stable solar-to-hydrogen efficiency for more than 1000 hours, peaking at 14%. The placement of an electrical shunt between the PV and the cathode catalyst layer allows the measurement of electrical current and calculation of faradaic efficiencies throughout the stability experiment. Concurrent logging of the operating voltage permits the deconvolution of performance losses caused either by PV shading due to condensation or cell dehydration, which can be used to automatically adjust the operating conditions such as the feed gas humidity.

Introduction

Team

Results, Highlights, and Accomplishments

Outlook

Future work hopes to build on this architecture, by incorporating Au cathode catalysts and PVs, with high open circuit voltages (VOC), to drive monolithic PEC CO2 reduction at a high efficiency.

Acknowledgments

This material is based upon work performed by the Joint Center for Artificial Photosynthesis, a DOE Energy Innovation Hub, supported through the Office of Science of the U.S. Department of Energy under Award Number DE-SC0004993.