Renewable Energy and Energy Storage
Room Naupaka Salon 1-3 - Session RE-TuP

Renewable Energy and Energy Storage Poster Session

RE-TuP-1 Graphene-Based Solar Cell Energy Harvester Intermittently Recharges a Battery-Powered Temperature Sensor System, ***Paul Thibado,*** *J. Mangum, T. Amin, S. Rahman, R. Kabir, A. Ashaduzzaman,* University of Arkansas*; G. Carichner, H. Do, D. Blaauw,* University of Michigan, Ann Arbor

Transparent, flexible, and electrically conductive graphene membranes hold great promise for multimodal energy harvesting. These sources include solar and ambient radiation, thermal, acoustic, and kinetic power. This poster reviews several graphene energy-harvesting avenues, then focuses specifically on the fabrication of graphene-based solar cells using mainstream semiconductor manufacturing methods. Our two-write maskless laser lithography process creates an array of graphene-based solar cells on a commercially available 100-mm silicon wafer topped with a 2-micron thick wet thermal oxide layer on top. The first pattern marks the wafer locations for etching the silicon dioxide down to the bare silicon substrate. The second pattern marks the wafer for gold traces and bonding pads. Once completed, the exposed silicon and graphene bonding pad are covered using a large-area graphene transfer method. The samples are then characterized using atomic force microscopy, optical microscopy, and photovoltaic measurements. We also used our energy harvester to charge a 3-volt rechargeable battery, which is simultaneously driving an ultralow power consuming custom temperature sensor system. This work was financially supported, in part, by a grant from the WoodNext Foundation, which is administered by the Greater Houston Community Foundation.

RE-TuP-2 A Study on Robust VO_2 Protection Layer and Defect Inactivation in $BiVO_4$ Photoelectrodes through Photoelectrochemically Transition-Metal Engineering, *H. Cho,* ***Kun Woong Lee,*** School of Advanced Materials Science & Engineering, Sungkyunkwan University (SKKU), Republic of Korea

Photoelectrochemical (PEC) cells for water splitting have garnered significant attention as a promising technology for solar-to-hydrogen energy conversion. Bismuth vanadate ($BiVO_4$), serving as the photoanode among photoelectrodes, stands out as a representative ternary oxide-semiconductor with several advantages. However, $BiVO_4$ photoanodes face controversial issues such as surface defects, performance limitations, and susceptibility to photo-corrosion instability. To address these challenges, we propose a groundbreaking protection layer. Based on deep understanding of the photo-corrosion mechanism regarding the dissolution of V^{5+} ions on $BiVO_4$ surface, we introduce a surface photoelectrochemical oxidation approach. By strategically introducing V^{5+} ions and H_2O_2 into the electrochemical electrolyte, we artificially modify photo-corrosion into advanced photo-oxidation. This induces a surface phase transition, leading to the formation of a novel vanadium oxide (VO_2) photoelectrochemical protection layer by transitioning the V^{5+} ions to the electrochemically favorable V^{4+} state. This layer is both conductive and ultrathin (~ 5 nm), while offering atomic-level controllability.

Characterizations of the $BiVO_4/VO_2$ photoanodes reveal enhanced carrier dynamics, with faster transport of interfacial charges (86%) and efficient transfer of photogenerated carriers through the VO_2 protection layer (95%). This innovative approach enables near-ideal performance, contributing to high stability and remarkable durability. Consequently, the $BiVO_4/VO_2/CoFeO_x$ photoanodes exhibit an impressive photocurrent density of 6.2 mA/cm^2 and an onset potential of 0.25 V_{RHE}. Additionally, they demonstrate an applied bias photon-to-current efficiency of 2.4% at 0.62 V_{RHE} and stable operation without serious performance degradation for 100 hours, showcasing vigorous active oxygen evolution.

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