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NATIONAL RENEWABLE ENERGY LABORATORY

NREL Develops $ZnSiP_2$ for Silicon-Based Tandem Solar Cells

Highlights in Research & Development

Combining an Earth-abundant chalcopyrite with a silicon layer could significantly boost conversion efficiency above that of single-junction silicon solar cells.

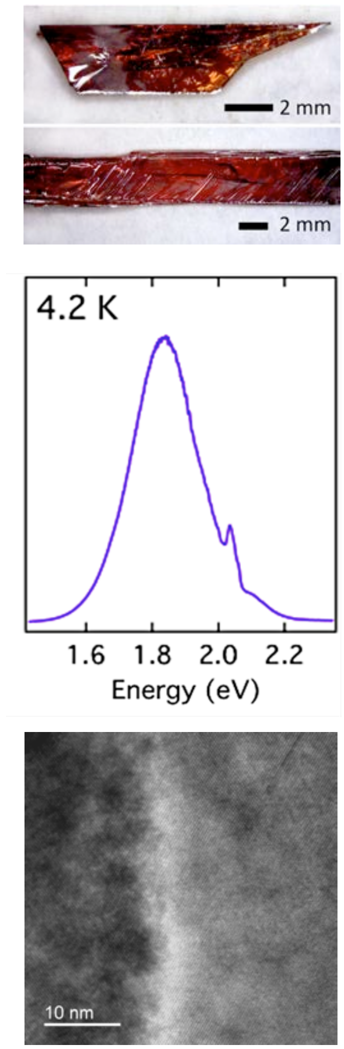
A current technological challenge in photovoltaics (PV) is to implement a lattice-matched, optically efficient material to be used in conjunction with silicon for tandem PV cells.

III-V materials currently hold the world-record conversion efficiencies for both single- and multijunction cells. Researchers at the National Renewable Energy Laboratory (NREL), collaborating with the Colorado School of Mines, are investigating materials that have similar properties to the III-V materials, but that are also lattice-matched to silicon. The II-IV-V_2 chalcopyrites are a promising class of materials that could satisfy both of these criteria.

NREL researchers have synthesized bulk single-crystalline $ZnSiP_2$ and characterized the material by structural and optical techniques. $ZnSiP_2$ is a member of the II-IV-V_2 class of materials and is known to have a bandgap of ~2 eV and a lattice mismatch with silicon of 0.5%. In addition, its elements are Earth abundant.

NREL has grown single crystals of $ZnSiP_2$ by a flux growth technique that results in thin platelets that are up to 1 mm thick, 4 mm wide, and 10 mm long. Structure and phase purity have been confirmed by X-ray diffraction. Initial optical measurements show strong luminescence and confirm the ~2-eV bandgap. The research has shown that there is no sub-bandgap absorption that would be detrimental to the silicon cell performance, and that $ZnSiP_2$ forms an epitaxial interface with Si.

This material, in conjunction with silicon PV, could find an application as a monolithic tandem layer, as well as a passivated contact or surface-passivation layer.



II-IV-V_2 chalcopyrite compounds such as $ZnSiP_2$ are closely related to III-V zinc-blende compounds. $ZnSiP_2$, which is lattice matched to Si, has been formed as single crystals (top). It has bright photoluminescence emission (middle) and forms an epitaxial interface with Si (bottom).

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Reference: Martinez, A.D.; Ortiz, B.R.; Johnson, N.E.; Krishna, L.; Choi, S.; To, B.; Norman, A.G.; Stradins, P.; Stevanovic, V.; Toberer, E.S.; Tamboli, A.C. (2014). "Development of $ZnSiP_2$ for Si-Based Tandem Solar Cells." *IEEE J. Photovoltaics*, forthcoming.

Key Research Results

Achievement

NREL researchers have synthesized bulk single-crystalline $ZnSiP_2$ and then characterized it by structural and optical techniques.

Key Result

X-ray diffraction by NREL confirms the structure and phase purity of the synthesized $ZnSiP_2$, and optical measurements show strong luminescence and confirm an ~2-eV bandgap.

Potential Impact

NREL predicts an increase in efficiency of up to 12% greater than that of single-junction silicon for a Si/$ZnSiP_2$ tandem cell.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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