



# Hawai'i Natural Energy Institute Research Highlights

## Advanced Materials Printable Photovoltaics

**OBJECTIVE AND SIGNIFICANCE:** The objective of this program is to develop high-throughput ink-based fabrication techniques for light-weight thin-film photovoltaics (PV). This approach has the potential to significantly reduce manufacturing costs and enable PV integration on non-conventional substrates (e.g., polyamides or woven fabrics).

**BACKGROUND:** Crystalline silicon has been leading the PV market for over 20 years. These panels, found primarily on roof-tops and centralized production plants, are easily recognizable by their architecture, with interconnected wafer-like solar cells laminated under a flat sheet of glass. Although well-suited for stationary electrical production, the mechanical rigidity and weight of silicon PV modules become a burden for mobile applications, where portability is more critical than performance. To this end, R&D efforts have focused on methods to integrate ultra-light and flexible thin film solar materials onto lightweight/flexible substrates, including plastics (polyamides) and fabrics. Such devices can generate enough electricity to power small electronic devices (phones and electronic tablets for civilians) and sensors (healthcare diagnosis instruments for military personnel), providing a reliable source of energy when needed.

**PROJECT STATUS/RESULTS:** With support from the Office of Naval Research, the research team at the HNEI Thin Films Laboratory is developing a unique method to print thin-film based PV. Rather than relying on conventional vacuum-based deposition tools, which are costly to operate and maintain, this technique uses liquid molecular inks which already contain all the raw chemical elements necessary for

the synthesis of the solar absorber. These inks can be easily printed and cured to form thin film solar absorbers.

This project is currently focused on a multi-compound alloy (CuInSe<sub>2</sub>, CISE), a material which meets the mechanical and weight requirements for light weight flexible PV. Recent results demonstrate that high-quality CISE solar absorbers can be achieved with this printing technology, leading to solar cells with power conversion efficiency over 8%. In addition, it has been demonstrated that additives, such as aluminum oxide, can be added to the molecular ink to passivate native defects in CISE during fabrication, yielding to efficiency as high as 11% (Septina, 2021). This technique is also being evaluated to synthesize other solar absorbers with promising properties for PV applications, including Cu(In,Ga)Se<sub>2</sub> and Cu(In,Al,B)Se<sub>2</sub>.

This project has produced the following publication:

- 2021, W. Septina, C.P. Muzzillo, C.L. Perkins, A.C. Giovanelli, T. West, K.K. Ohtaki, H.A. Ishii, J.P. Bradley, K. Zhu, N. Gaillard, [In situ Al<sub>2</sub>O<sub>3</sub> incorporation enhances the efficiency of CuIn\(S,Se\)<sub>2</sub> solar cells prepared from molecular-ink solutions](#), Journal of Materials Chemistry A, Vol. 9, Issue 16, pp. 10419-10426.

*Funding Source:* Office of Naval Research

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*Last Updated:* November 2021

