Use of Direct Write Methods for Reduced Cost Photovoltaics

Maikel F.A.M. van Hest[1], Alex Miedaner[1], Calvin J. Curtis[1], Jennifer Leisch[1], Peter Hersh[1] Ken Steirer[2], Robert Pasquarelli[2], Jennifer A. Nekuda[2], Ryan P. O'Hayre[2], and David S. Ginley[1]

[1]National Renewable Energy Laboratory, Golden, CO 80401, [2]Colorado School of Mines, Golden, CO 80401

Abstract

Photovoltaics are becoming an increasing part of the energy supply mix, however to have a really significant impact they must become cost competitive with more conventional energy sources. Direct write methods could help toward this significant cost reduction. We are investigating solution precursors and ink based atmospheric deposition approaches to a variety of solar cell materials. The first application we are studying is inkjet printing of contacts for Si, CIGS and organic photovoltaics. We have developed metal organic decomposition inks for silver, nickel, copper and aluminum for example. Conductivities close to that of bulk metals were obtained. In this field the use of laser processing has been explored. The second application is the formation of the absorber layer in $CuInSe_2$ (CIS) and CdTe based photovoltaics. CIS/CIGS is the most efficient thin film photovoltaic technology, but typically employ capital intensive PVD materials deposition and subsequent selenization steps. Our approach uses liquid based precursors that can be inkjet printed and processed under atmospheric conditions. For CIGS various precursors were identified to produce In_2Se_3, Cu_2Se, Ga_2Se_3, $InGaSe_3$, $CuInSe_2$ and $CuIn_xGa_{1-x}Se_2$ films without a selenization step on various substrates. For CdTe various solution precursors have been developed that produce solar cell grade thin film CdTe. Details of film deposition, processing and devices will be discussed. The third application is in the field of organic photovoltaics. Here inkjet printing is used to deposit the photoactive layer such as a polythiophene, for example P3HT, and the conducting contact layer such as PEDOT/PSS. Details will be shown on how solvents can influence the quality of the printed material. Direct write processing of these materials may be enabling for this technology leading to all printed thin film photovoltaics.

Author Biography

Maikel van Hest holds a Ph.D. in applied plasma physics from the Eindhoven University of Technology, the Netherlands. He is a senior scientist in the Process Development and Advanced Concepts group at the National Renewable Energy Laboratory. His research interests include liquid precursor approached to materials, especially materials with photovoltaic applications. His research focuses on ink and process development and deposition techniques. He also is interested in exploring materials phase space by combinatorial research methods.