doi:10.1017/S1431927615005644 Paper No. 0485 Microsc. Microanal. 21 (Suppl 3), 2015

Studying Perovskite-based Solar Cells with Correlative In-Situ Microscopy

J. A. Aguiar[1], S. Wozny[2], W. Zhou[2], H. Guthrey[1], H. Moutinho[1], A. G. Norman[1], C. S. Jiang[1], J. Berry[1], K. Zhu[1], T. Holesinger[3], and M. M. Al-Jassim[1]

[1.] National Renewable Energy Laboratory, Golden, CO, 80401
[2.] University of New Orleans, New Orleans, LA, 70148
[3.] Los Alamos National Laboratory, Los Alamos, NM, 80465

Hybrid organic-inorganic perovskite based solar technologies are generating a great deal of interest in the materials community. In this work, we plan to discuss our ongoing work to characterize new synthesis routines and processes to generate sustainable and reliable perovskite-based materials whose properties are significantly better than the current state of the art. In particular, we are utilizing the latest advances in high-resolution analytical and in-situ microscopy to characterize these emerging photovoltaic materials and their interfaces, defects, and discrete paths to crystallization.

There are longstanding interests in the relation between growth, microstructure, defects, electronic structure, and electro-optical activity for two reasons. The first reason is studies suggest there is a great deal of variability in the growth of these materials. The fundamental origins however remain nascent due to the current novelty of these materials and the complexities associated with studying beam-sensitive materials. Furthermore, beyond static conditions as shown in Figure 1, observing transient behavior associated with the growth of these materials is of increasing importance to set future research directions for generating next generation perovskite-based solar cells. The second reason is a more complete understanding of the microstructure, growth defects, and doping behavior and how they affect the efficiency of devices will be crucial in developing both sustainable and efficient perovskite-based solar technology.

This talk will present the correlations between our current ongoing observations and measurement of the optical properties, microstructure, defects, and crystallization associated with perovskite-based solar cells. The guided use of the latest high-resolution state-of-the-art cathodoluminescence and in-situ (scanning) transmission electron microscopy (S/TEM) techniques to examine growth, crystallization, and material stability of this exciting class of materials will also be discussed at length [1].

Reference:

[1] This work was supported by the National Renewable Energy Laboratory as a part of the Non-Proprietary Partnering Program under Contract No. DE-AC36-08-GO28308 with the U.S. Department of Energy.

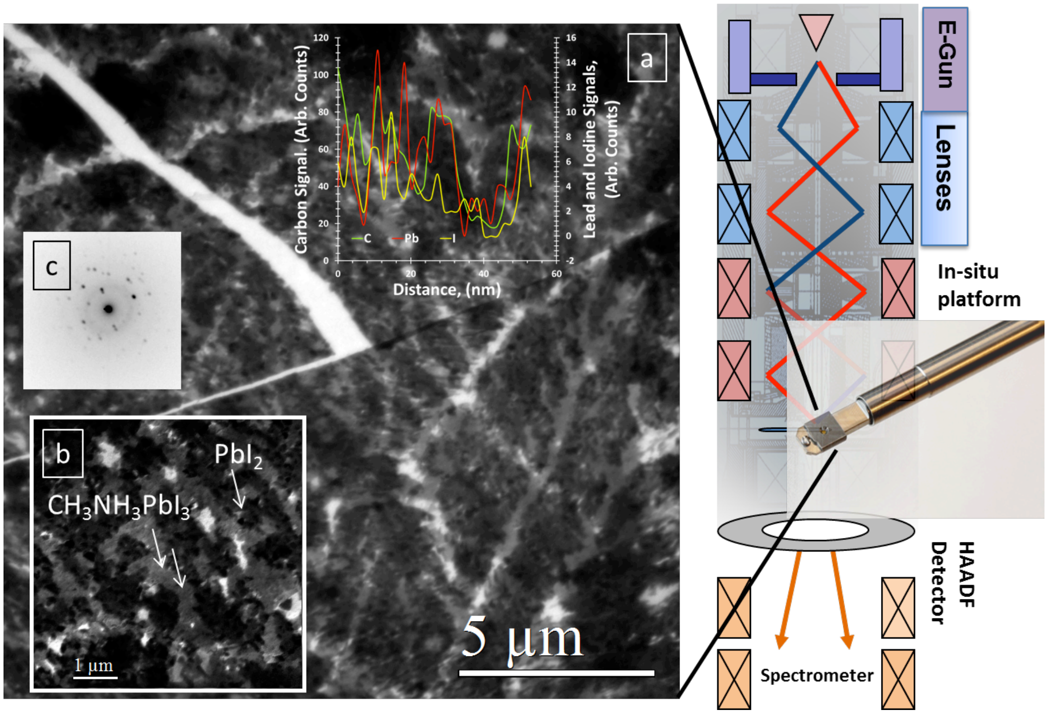

Figure 1. (a) Above is an overview diffraction contrast TEM image of an as grown hybrid organic-inorganic perovskite film. (b) Based on the image contrast and subsequent chemical profiling with lower voltage STEM-based imaging we have identified that the perovskite films grown to date are not phase pure, but contain regions of PbI_2 (dark contrast) and $CH_3NH_3PbI_3$ (light contrast). (c) The crystallinity of the film is further revealed with selected area electron diffraction, where both PbI_2 and $CH_3NH_3PbI_3$ diffraction spots are revealed. (d) These results highlight the potential use of in-situ based microscopy where the effects of humidity, temperature, and solvent chemistry could be varied to lock-in on possible combinations to grow phase pure and potentially more stable perovskite based solar cells.

https://doi.org/10.1017/S1431927615005644 Published online by Cambridge University Press