Inkjet-Printed Perovskite Solar Cells, Drop by Drop: Lead-Reduced $Cs_xRb_{1-x}Pb_ySn_{1-y}I_3$ Absorbers

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Abstract

Scalable deposition is the missing link between high-efficiency perovskite solar cells and industrial deployment. Inkjet printing, a digital, mask-free and low-waste drop-on-demand process, is particularly attractive for lead-reduced tin–lead perovskites, whose narrower bandgap approaches the single-junction optimum.

Building on our recent work on inkjet-printed ZnO thin films, we develop inkjet-printed all-inorganic $Cs_xRb_{1-x}Pb_ySn_{1-y}I_3$ absorbers, with $CsPb_{0.5}Sn_{0.5}I_3$, $Cs_{0.5}Rb_{0.5}Pb_{0.5}Sn_{0.5}I_3$ and $RbPb_{0.5}Sn_{0.5}I_3$ as representative compositions. Inks are tuned to the printability window $1 < Z < 10$ ($Z = 1/Oh$), while drop spacing, platen temperature and annealing are optimized to control the coffee-ring effect and grain growth and to limit Sn^{2+} oxidation. The influence of Rb^+ substitution on lattice, phase stability, morphology and optical absorption is examined by XRD, SEM, TEM, UV–Vis and photoluminescence.

The printed absorbers are integrated into planar n–i–p solar cells (glass/FTO/ZnO/perovskite/HTL/Au) in which the ZnO electron transport layer is also inkjet-printed. Being free of organic cations, the absorber is chemically compatible with ZnO, whose basic surface degrades methylammonium-based perovskites. Device measurements link composition and printing conditions to photovoltaic performance, positioning inkjet printing as a credible route toward fully printed, lead-reduced perovskite solar cells.

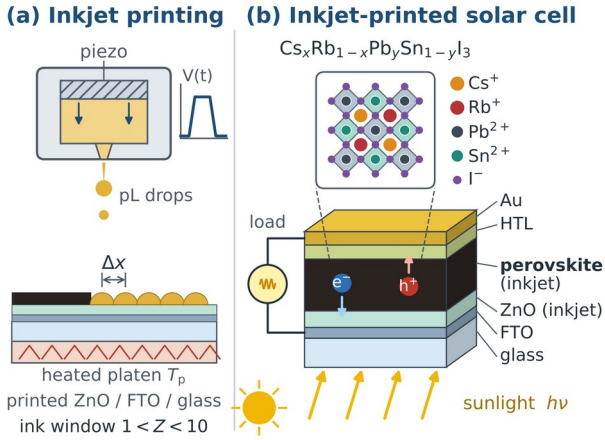

Fig. 1 (a) Drop-on-demand inkjet printing of the absorber on printed ZnO. (b) Inkjet-printed n–i–p solar cell under illumination, with a zoom on the $Cs_xRb_{1-x}Pb_ySn_{1-y}I_3$ lattice.

Recent Publications

1. Bouich A., Cerutti Torres J., Khattak Y. H., Baig F., Marí-Guaita J., Marí Soucase B., Mendez-Blas A., Palacios P., *Surf. Interfaces* 40 (2023) 103159.
2. Bouich A., Cerutti Torres J., Chfii H., Marí-Guaita J., Khattak Y. H., Baig F., Marí Soucase B., Palacios P., *Sol. Energy* 250 (2023) 18-32.
3. Bouich A., Marí-Guaita J., Baig F., Khattak Y. H., Marí Soucase B., Palacios P., *Nanomaterials* 12 (2022) 3027.
4. Bouich A., Ullah S., Marí B., Atourki L., Touhami M. E., *Mater. Chem. Phys.* 258 (2021) 123973.
5. Khattak Y. H., Bouich A., Process–structure–property relationships in inkjet-printed ZnO thin films: decoupling the effects of substrate temperature and layer number.

Biography



Prof. Dr. Amal Bouich is a professor of physics at the Faculty of Sciences, Ibn Tofail University, Morocco, and a member of the Laboratory of Advanced Materials and Process Engineering. She received her Ph.D. (Cum Laude, International Mention) from the Universitat Politècnica de València (UPV), Spain, and Ibn Tofail University, then held a Margarita Salas postdoctoral fellowship at UPV within the Group of Optoelectronics and Semiconductors (GOPS). She has published more than 140 papers (h-index 33, i10-index 68), given 53 invited or plenary conference talks, received the Best Thesis Award at the E-MRS 2021 Fall Meeting, and supervises six Ph.D. students.

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