How Important is the Organic Part of Lead Halide Perovskite Photovoltaic Cells? Efficient $CsPbBr_3$ Cells

Michael Kulbak, David Cahen, Gary Hodes

Department of Materials and Interfaces, Weizmann Institute of Science, Rehovot 76100, Israel

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WEIZMANN INSTITUTE OF SCIENCE

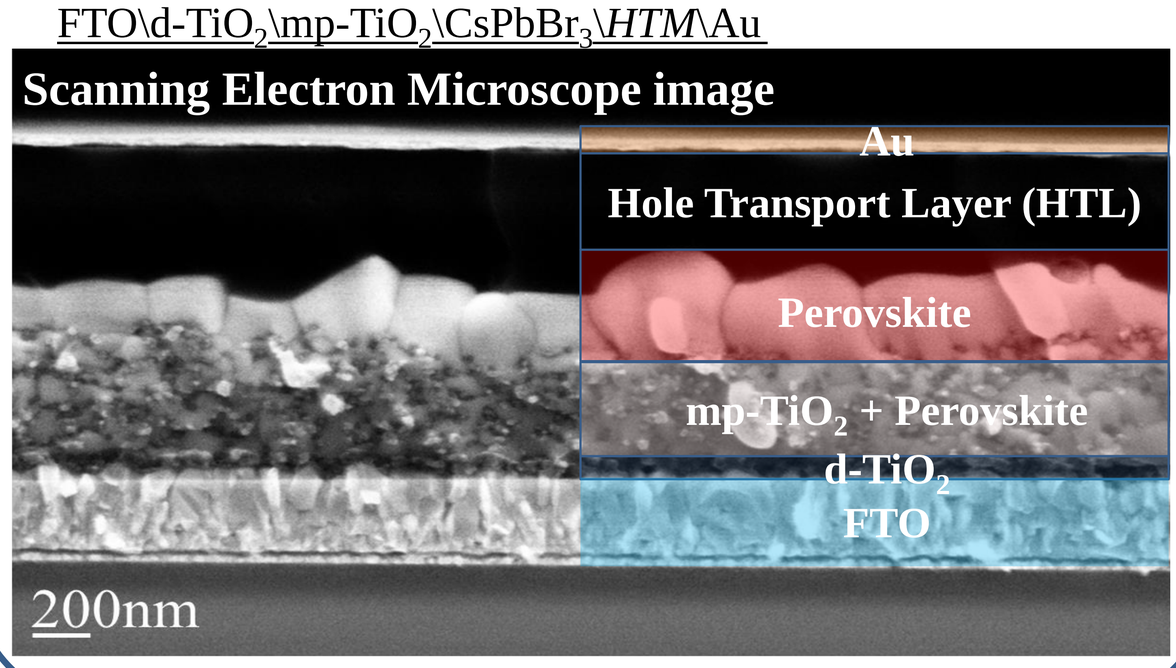
Background

To date, there are no reports on high band gap (> 2 eV) all-inorganic perovskite solar cells. $CH_3NH_3PbBr_3$-based devices have shown promising device parameters with open-circuit voltages surpassing 1.5 V [1], but is the organic cation really necessary to obtain high quality devices? $CsPbBr_3$, a high bandgap semiconductor with perovskite structure at standard temperature and pressure, has been estimated to have an electron mobility of ~1000 $cm^2/(V\ s)$ and comparable electron/hole lifetimes of 2.5 μs [2], emphasizing that it has potential as a promising absorber in solar cells. Here we discuss if perovskites with an inorganic A cation can form light absorbers with PV properties, comparable to those with an organic (e.g., alkyl ammonium) one, in particular in terms of the high open circuit voltages that are an important feature of these cells [3].

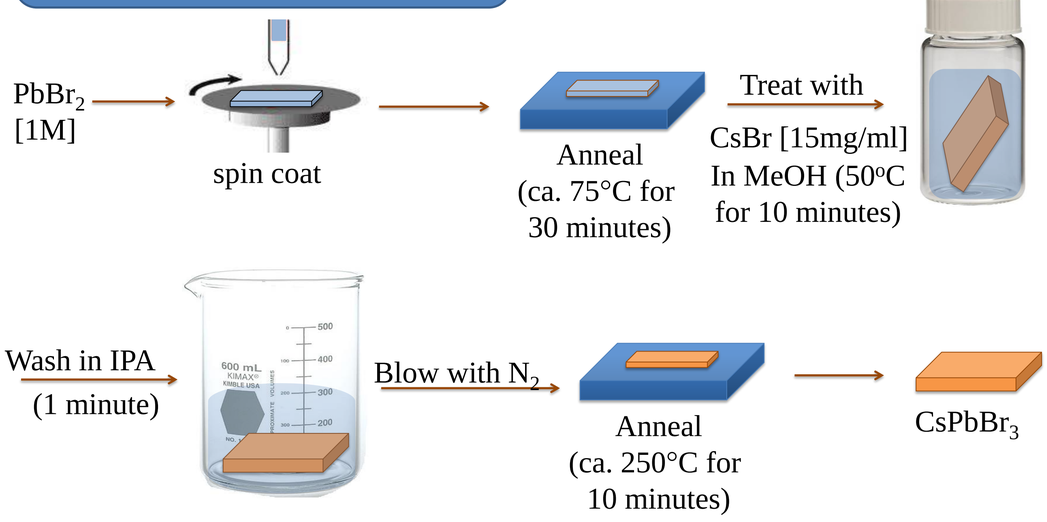
[1] E. Edri et al., *J. Phys. Chem. Lett.* (2014), 5, 429-433.
[2] C.C. Stoumpos et al., *Cryst. Growth Des.* (2013), 13, 2722-2727.
[3] M. Kulbak, D. Cahen and G. Hodes, *J. Phys. Chem. Lett.* (2015), 6, 2452–2456.

Device Structure

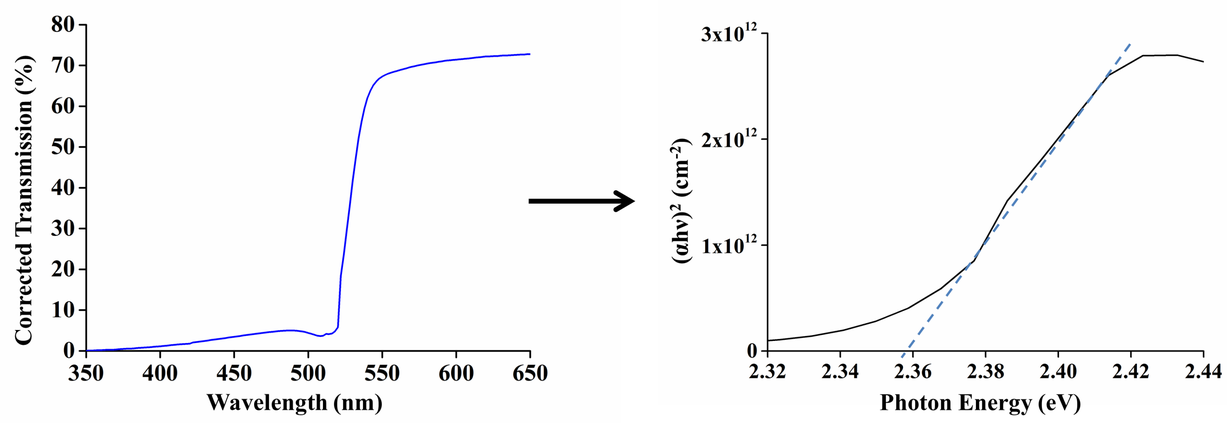
FTO\d-TiO_2\mp-TiO_2\$CsPbBr_3$*HTM*\Au



Experimental

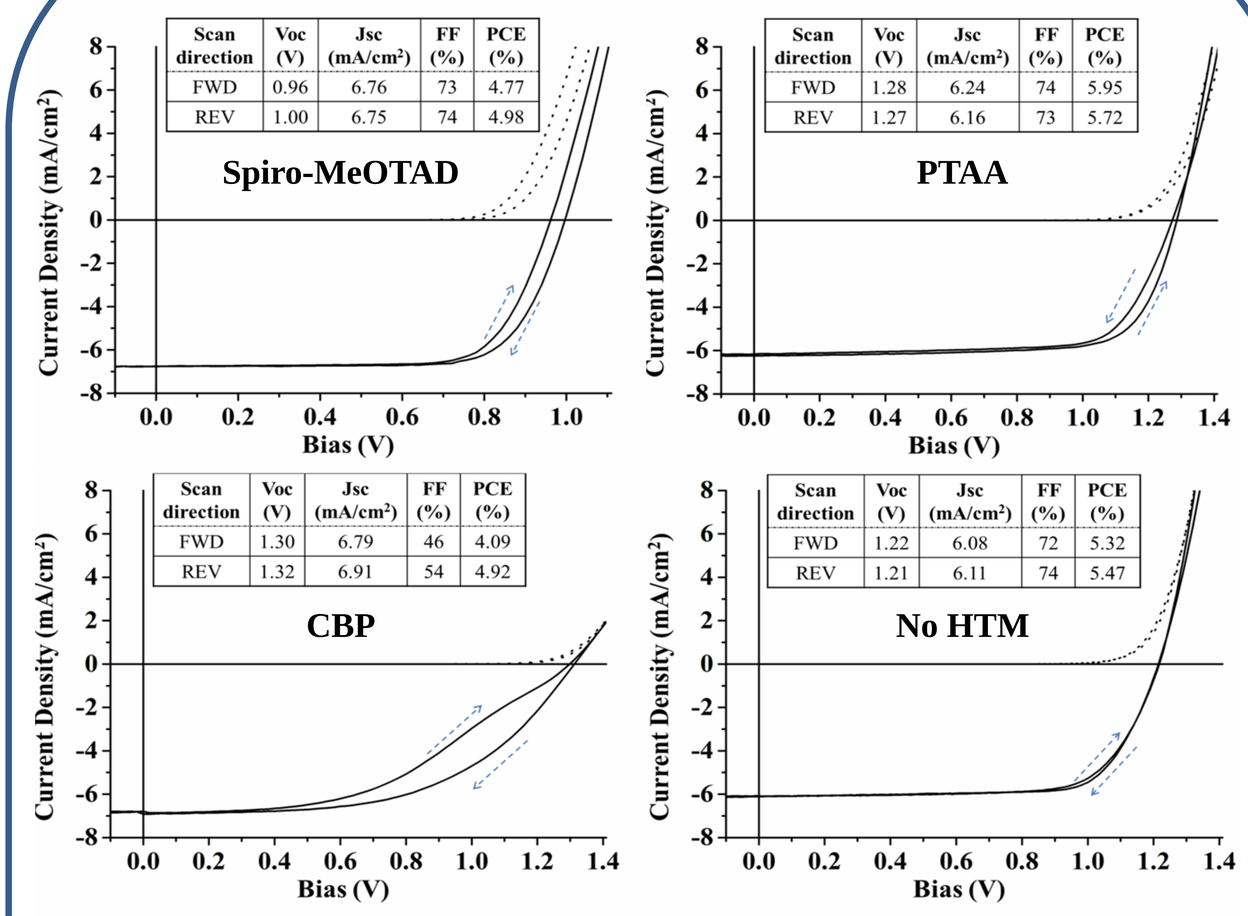


Optical properties of $CsPbBr_3$



- Films of $CsPbBr_3$ on FTO\d$TiO_2$\mp-TiO_2 show a drop in transmission at ca. 520 nm, correlating to a calculated direct bandgap of 2.36 eV.

Device I-Vs with different HTLs



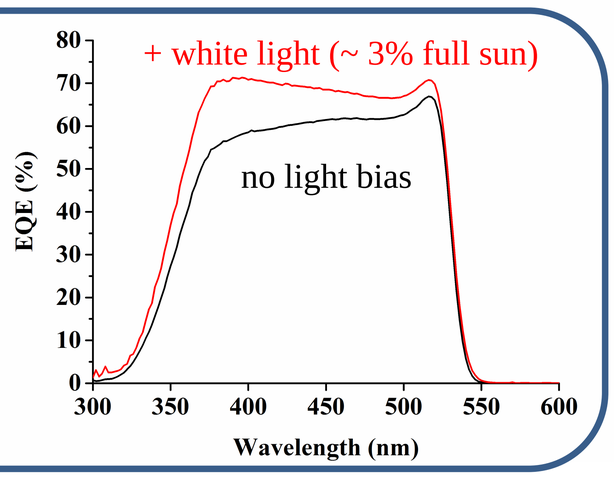
HTM	Spiro	PTAA	CBP
HOMO [eV]	5.0	5.2	5.7

- The deeper lies the HTL HOMO level, the higher is the V_{OC}.
- Devices without HTL layer work just as well as cells with it.
- No significant hysteresis is seen except with CBP.
- 1.3 V V_{OC} values are still below the top, 1.55 V, $MAPbBr_3$ one.

EQE

EQE of $CsPbBr_3$\PTAA device:

- White light increases the EQE close to 70 %.
- The EQE value yields an equivalent J_{SC} that agrees with the directly measured result (IV measurements).



Conclusions

We show $CsPbBr_3$ can have a PV performance that does not fall below that of $CH_3NH_3Br_3$, incl. encouraging V_{OC} values, comparable to our early results with the hybrid perovskite.

Acknowledgements

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gary.hodes@weizmann.ac.il, david.cahen@weizmann.ac.il