Organo-metallic hybrid perovskite for oxygen sensing

Marc-Antoine Stoeckel[1], Marco Gobbi[1], Sara Bonacchi[1], Fabiola Liscio[2], Laura Ferlauto[1], Emanuele Orgiu[1,3], Paolo Samorì [1]

[1]Université de Strasbourg, CNRS, ISIS F-67000 Strasbourg, France
[2]CNR - IMM Sezione di Bologna Via P. Gobetti 101 40129 Bologna Italy
[3]INRS-Centre Énergie Matériaux Télécommunications, 1650 Blv. Lionel-Boulet, J3X 1S2 Varennes (Québec)

E-mail: marc-antoine.stoeckel@etu.unistra.fr

Organo-metallic hybrid perovskite materials are unique materials that feature extremely high power conversion efficiency, therefore holding great promise for low-cost and up-scalable device applications in opto-electronics.[1] Devices based on methylammonium lead iodide ($MAPbI_3$) were successfully exploited as resistive sensor of ammonia or optical sensors for humidity[2,3]. It is also reported that $MAPbI_3$ can strongly interact with oxygen gas, leading to a peculiar increase of its photoluminescence[4], and that Pb-O bond formation could be responsible for such an enhancement[5].Here we explore the electrical response of $MAPbI_3$ in two-terminal devices under a controlled atmosphere with a variable amount of oxygen (Fig. 1).

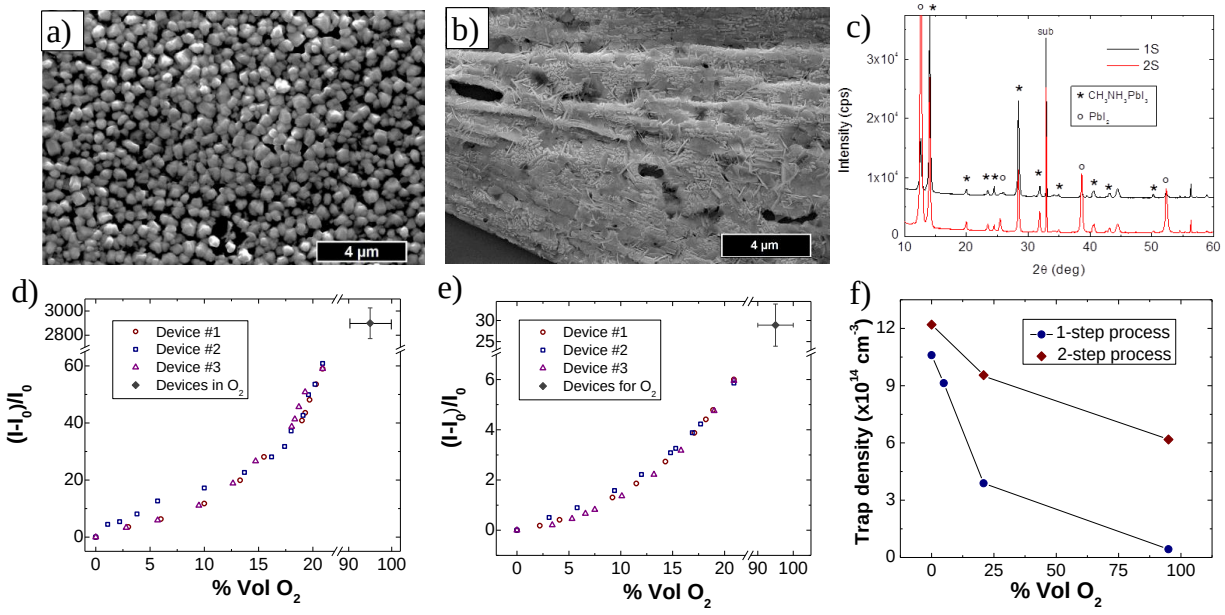

Figure 1. a) SEM image of a two-step film and b) of a one-step film, c) XRD spectra of both samples, d) sensor sensitivity versus O2 concentration for two-step e) and one-step perovskite, f) number of charge traps in the perovskite films at different oxygen concentration.

The electrical resistance of the perovskite was found to be strongly correlated with gas percentage in the environment. The observed effect can be ascribed to a fully reversible passivation of the vacancies contained within the perovskite. When oxygen molecules fill an increasing number of trapping sites, the device current increases. The two-terminal device exhibit strong oxygen sensitivity with wide detection range from few hundred of ppm to 100 %. Finally, $MAPbI_3$ oxygen

sensitivity was found to be highly related to the morphology adopted in the thin film, through the deposition process used to prepare devices.

Funding:

This work was supported by the EC from the University of Strasbourg, the Agence Nationale de la Recherche through the LabEx project Chemistry of Complex Systems (ANR-10-LABX-0026_CSC) and the International Center for Frontier Research in Chemistry (icFRC).

Acknowledgement:

We thank Dr. A. Alipandri for valuable discussion and Dr. J. Raya for his help through the conception of the setup.

References:

[1] X. Li, D. Bi, C. Yi, J.-D. Décoppet, J. Luo, S. M. Zakeeruddin, A. Hagfeldt, M. Grätzel, *Science* **2016**, aaf8060.
[2] C. Bao, J. Yang, W. Zhu, X. Zhou, H. Gao, F. Li, G. Fu, T. Yu, Z. Zou, *Chem Commun* **2015**, *51*, 15426.
[3] L. Hu, G. Shao, T. Jiang, D. Li, X. Lv, H. Wang, X. Liu, H. Song, J. Tang, H. Liu, *ACS Appl. Mater. Interfaces* **2015**, *7*, 25113.
[4] J. F. Galisteo-López, M. Anaya, M. E. Calvo, H. Míguez, *J. Phys. Chem. Lett.* **2015**, *6*, 2200.
[5] W. Kong, A. Rahimi-Iman, G. Bi, X. Dai, H. Wu, *J. Phys. Chem. C* **2016**, *120*, 7606.