New efficient encapsulation methods to improve the environmental stability in efficient perovskite solar cells.

F. Javier RAMOS,[1,2]* Amelle REBAI,[1,2] Sophie BERNARD,[2,3] Sebastien JUTTEAU,[2,3] Nathanaelle SCHNEIDER,[1,2] Tony MAINDRON,[4] Thomas GUILLEMOT,[2] Nicolas LOONES,[2,3] Cédric BROUSSILLOU,[5] Gilles GOAER,[5] Jean ROUSSET[1,2,3]

[1] IPVF, Institut Photovoltaïque d'Ile-de-France, Palaiseau, France. [2] IRDEP, Institute of Research and Development for Photovoltaic Energy, CNRS-EDF Chimie ParisTech, Chatou, France. [3] EDF R&D, Chatou, France. [4] CEA Leti Grenoble, France. [5] Photowatt, Bourgoin-Jallieu, France
* Email: javier.mellado@ipvf.fr

Perovskite solar cells (PSC) have emerged during the last five years as one of the PV technologies with more brilliant future due to their versatility and exceptional optical and electrical properties[1]. In spite of the remarkable results pushing the efficiencies >22%, some important aspects for their future commercialization have remained less explored. For instance, although some approaches of encapsulation systems can be found in literature[2,3], a final solution providing long term stability is still needed.

In this work we report two encapsulation processes showing much higher long-term stability in terms of performance than the referential non-encapsulated cells (Figure 1). The first system consists of an ultrathin Al_2O_3 film made by Atomic Layer Deposition (ALD) while the second is an industrial process using a polymeric film commercially available. A detailed study about evolution of electrical and photovoltaic properties in both systems will be presented. In brief, encapsulated devices showed outstanding improved properties under ambient conditions in comparison with non-encapsulated ones employed here as reference since neither perosvkite nor Spiro-OMeTAD degradation was observed for both encapsulation methods.

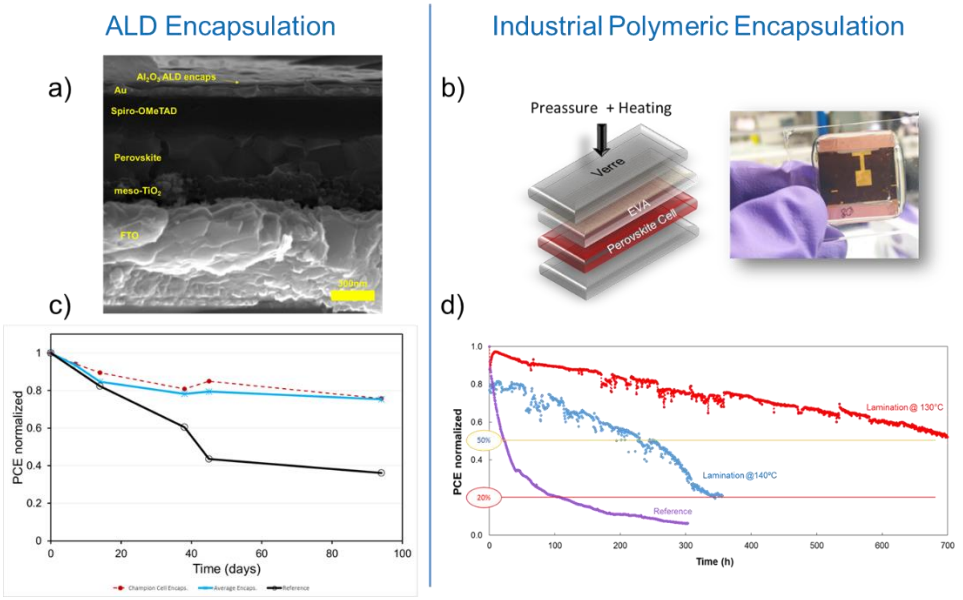

Figure 1. a) Cross-sectional SEM of a PSC with ultrathin Al_2O_3 ALD encapsulation. **b)** Scheme of a PSC with industrial polymeric encapsulation with a photograph of the final encapsulated device. Power conversion efficiency evolution (normalized) of the PSC under ambient conditions with **c)** ultrathin Al_2O_3 ALD encapsulation and **d)** industrial polymeric encapsulation, compared with a reference non-encapsulated cell.

References

1 J. S. Manser, J. A. Christians and P. V. Kamat, *Chem. Rev.*, 2016, **116**, 12956–13008.
2 F. J. Ramos, D. Cortes, A. Aguirre, F. J. Castano and S. Ahmad, *IEEE 40th PVSC*, 2014, 2584–2587.
3 F. Matteocci, L. Cinà, E. Lamanna, S. Cacovich, G. Divitini, P. A. Midgley, C. Ducati and A. Di Carlo, *Nano Energy*, 2016, **30**, 162–172.