ASIA-PACIFIC SOLAR RESEARCH CONFERENCE

The Effect of Pressing Pressure on the Performance of Perovskite Solar Cells

Lei Shi[1], Meng Zhang[1], Yongyoon Cho[1], Trevor L. Young[1], Dian Wang[1], Haimang Yi[1], Jincheol Kim[1], Shujuan Huang[1,2], and Anita W. Y. Ho-Baillie[1,2]

[1]The Australian Centre for Advanced Photovoltaics (ACAP), School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Sydney 2052, Australia
[2]School of Engineering, Macquarie University, Sydney 2109, Australia
E-mail: a.ho-baillie@unsw.edu.au

Metal halide perovskite solar cells (PSC's) have undergone remarkably rapid progress with their power conversion efficiency (PCE) increasing from 3.8 % to 24.2 % [1] in merely a decade. Enormous research effort has been devoted to performance improvement, focussing on optimising perovskite composition, varying material preparation and cell fabrication processes and new device architectures. However, there has been little investigation of the effect of post-fabrication processes such as tabbing, encapsulation or packaging processes on device PCE. For Si and thin-film solar modules, an encapsulation process typically involves heating the module / encapsulant stack in a vacuum laminator at elevated temperature and pressing the stack by the laminator. Therefore, it is essential to understand the effect of the laminating process on perovskite device performance and stability.

In this work, the effect of pressing at room temperature, by either the vacuum laminator or the spring-loaded clamps, on the performance of mesoporous PSC's was studied. Cells with the state-of-the-art architecture glass/FTO/c-TiO_2/mp-TiO_2/perovskite/hole-transport-layer (HTL)/gold were used in this study. It was found that pressing under the condition typically used for encapsulation [1] is beneficial for these PSC's, improving their PCE consistently by more than 7 % relative on average (Figure 1 & 2). Moreover, the PCE distribution of one batch of PSC's was narrowed after a few weeks' of pressing, suggesting improved repeatability (Figure 2). The effect of pressing was characterised by light current density-voltage measurement (LJV), cross-sectional scanning electron microscopy (SEM), X-ray diffraction (XRD) and electrical impedance spectroscopy (EIS). The PCE enhancement was due to higher fill factor which was mainly from improved series resistance, lower recombination and lower hysteresis. The lack of changes in the XRD patterns suggested that the effect of pressing on the perovskite layer was minimal. Improvement in performance by pressing was mainly due to improved perovskite/HTL interfaces as evidenced by increased recommendation resistance which also helps explain the reduced hysteresis. It was found that pressing for long term at a pressure of 400 to 500 mbar was appropriate while higher pressure at 1000 mbar was detrimental (Figure 3). Moreover, pressure must be maintained to maintain the PCE improvement (Figure 2).

Pressing is an essential part of an encapsulation process and this work demonstrates the beneficial effect of pressing on PSC's. These findings have important implications for the development of low-cost encapsulation processes for perovskite solar cells and for optimising the lamination processes.

References

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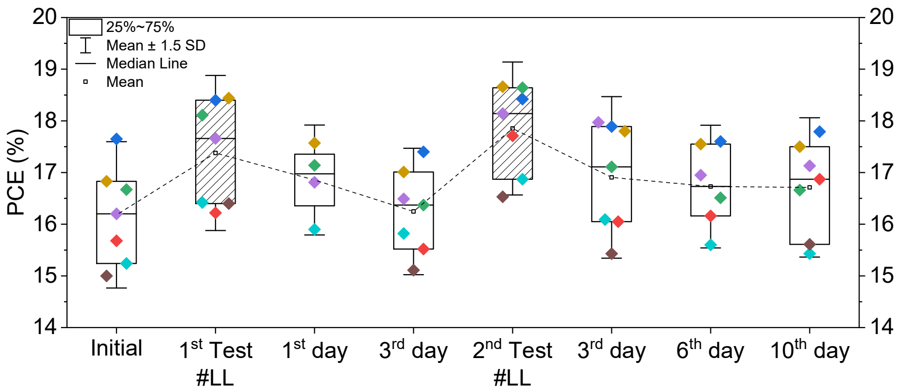

Figure 1 PCE for before (“Initial”); immediately after (“1st Test #LL”) the 1st pressing test #LL (#LL = 0.4 bar for 5 min by laminator) and relaxed for 1 day (“1st day”) and 3 days. The same pressing test was applied again (“2nd Test #LL”) and relaxed for up to 10 days.

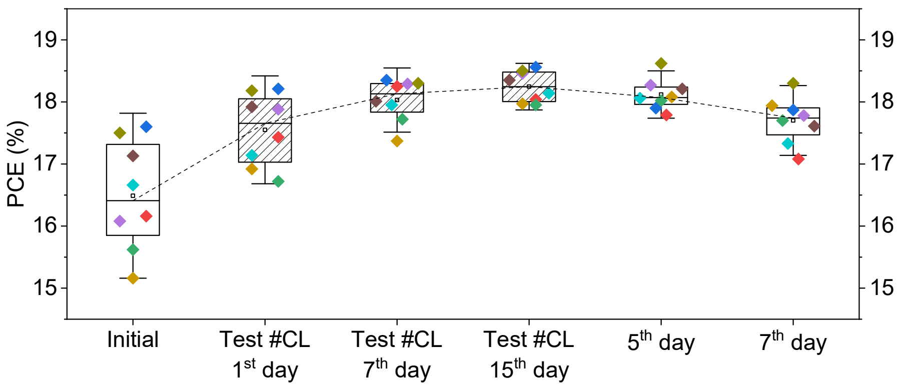

Figure 2 PCE evolution of before (“Initial”) and during 15 days of continuous pressing Test #CL (#CL = pressing by clamping at 0.4-0.5 bar). After that, pressing was removed and the cells were measured again after on the 5th day and 7th days of “relaxation”.

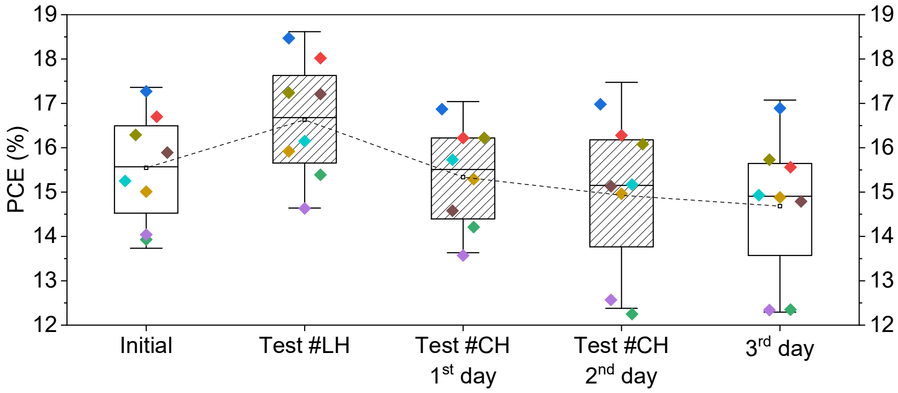

Figure 3 PCE for before (“Initial”); immediately after Test #LH (#LH = 1 bar for 5 min by laminator), on the 1st (Test #CH 1st day) and 2nd (Test #CH 2nd day) day of clamp test (1 bar). After that, pressing was removed and the cells were measured 3 days after.