In operando photoluminescence and I(V) characterization of the ageing of perovskite solar cells

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Despite their good efficiencies and relatively simple synthesis process, perovskite-based solar cells encounter stability issues during their operation, limiting their commercial development. Degradation has naturally attracted a large attention, but the plethoric literature highlights the complexity of the topic. It appears indeed that degradation can be induced by many different factors (light (UV in particular), high temperature, moisture, and oxygen) [1], with different influences whether applied together or separately. Degradation varies also strongly with the perovskite composition, the cell architecture or the operating conditions. Degradation investigation thus requires adequate characterization techniques.

While many approaches have already been considered [2,3], most studies perform post-mortem analysis and compare the system's performances before and after aging. By contrast, in operando characterization allows to follow the degradation dynamics and to investigate its kinetics. For this purpose, we have set up a coupled I(V)-photoluminescence (PL) characterization bench inside a climate chamber (solar simulator, temperature and humidity control), allowing to periodically acquire PL spectra and I(V) curves during the simulated ageing.

In this study we focus on the damp heat tests from ISOS protocols [6] applied to encapsulated perovskite solar cells: ISOS-D-3 and ISOS-V-3. By following the kinetics of the evolution of PL and electrical parameters extracted from I(V) curves, namely the open-circuit voltage (V_{oc}), the short-circuit current (J_{sc}) and fill-factor (FF), we can decorrelate between absorber material and electrical contact degradations (see the Figure). We also study the degradation effects of each stressor separately to explain the kinetics of the combined stressors ageing.

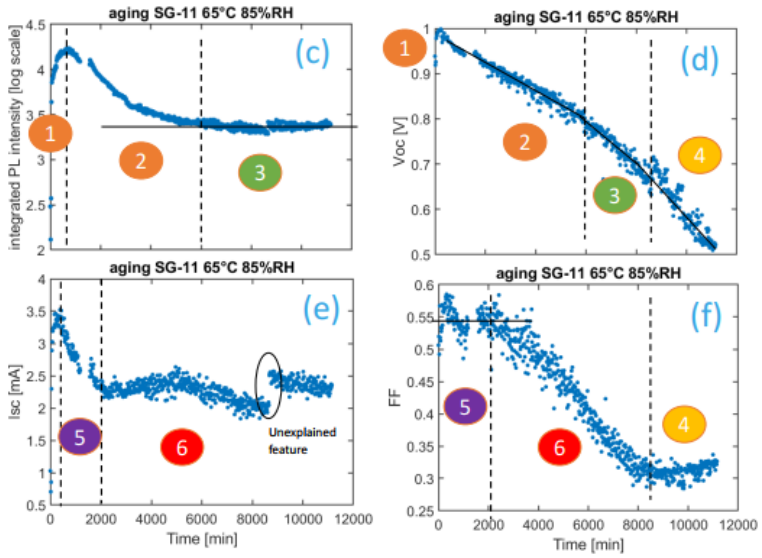

Figure 1 : PL and IV measurements results, interval between measurements: 15 minutes. Region 1: enhancement of all parameters, region 2: degradation of PL intensity and V_{oc}, region 3: stabilization of PL meaning no degradation of perovskite material but decrease of V_{oc} meaning a degradation of the build-in voltage thus at one of the contacts, region 4: more drop in V_{oc} while others parameters are constant, regions 5 and 6: either J_{sc} or FF decreases while the other is constant revealing different resistances effects

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