Correlative microscopy and spectroscopy of perovskite mini-modules: degradation analysis

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Objective

The purpose of this work was to characterize perovskite thin films with and without FACl additives in the active perovskite layer using various methods . In addition Ultrafast Spectroscopy was employed to detect changes in carrier relaxation dynamics occurring at different degradation stages during their outdoor exposure at real environmental conditions.

Methodology

- Encapsulated thin film perovskite devices were utilized with two different compositions:
  i. Type A: $Cs_{0.18}FA_{0.82}PbI_{20.82}Br_{0.18}$ without FACl in active layer
  ii. Type B: $FA_{0.9}Cs_{0.1}PbI_{2.865}Br_{0.135}$ with 5mol% excess FA and Cl
- Characterisation Techniques used were Scanning Electron Microscopy (SEM), conductive Atomic Force Microscopy (c-AFM), femtosecond transient transmission.

Results

Scanning Electron Microscopy

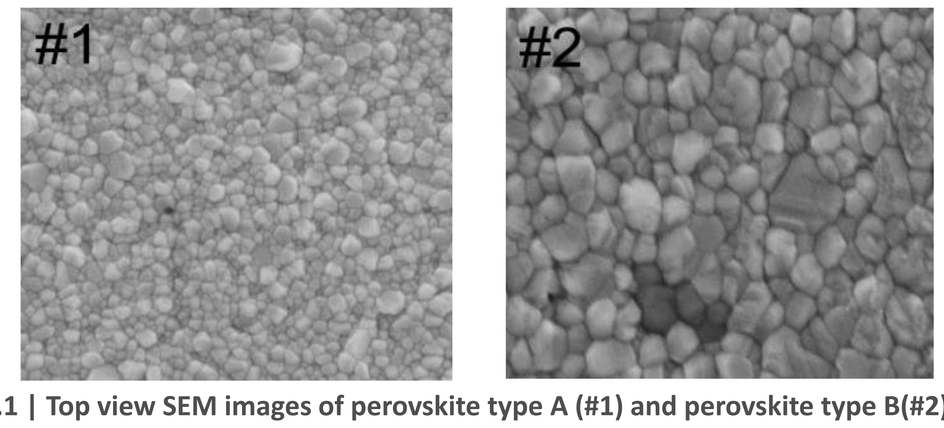

Fig.1 | Top view SEM images of perovskite type A (#1) and perovskite type B(#2).

Conductive Atomic Force Microscopy

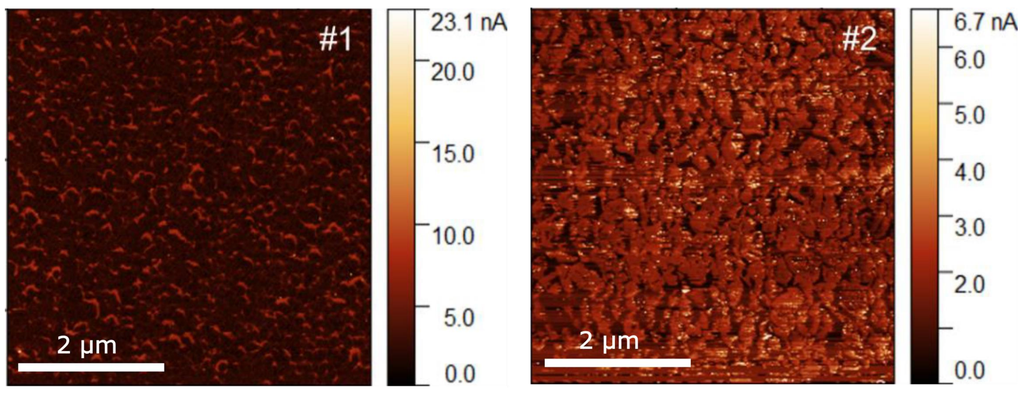

Fig.2 | Current maps obtained with c-AFM for type A (#1) and type B (#2).

Ultrafast spectroscopy measurements

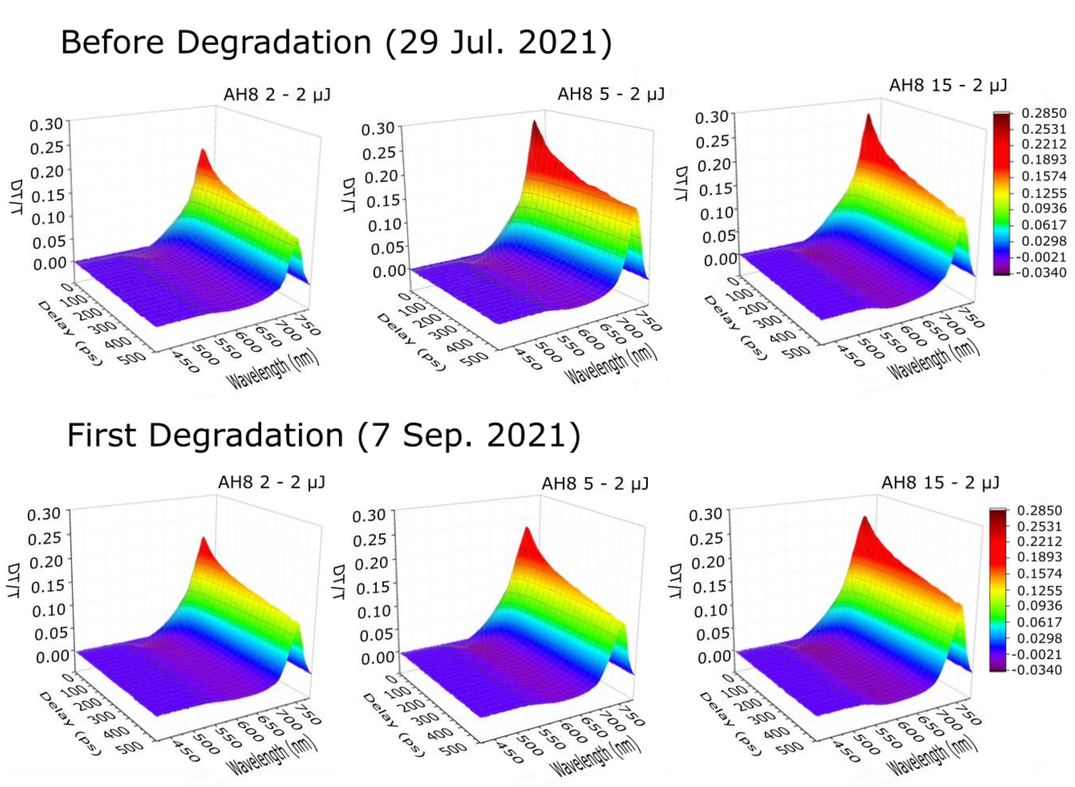

Fig. 3 | Pump-probe differential transmission data on three selected samples taken on 29th of July 2021 (top) and 7th September 2021 (bottom). Pump was set at 400 nm and fluence at 200 µJ/cm² for all samples.

Focused Ion Beam (FIB) Milling – SEM: Degradation Analysis

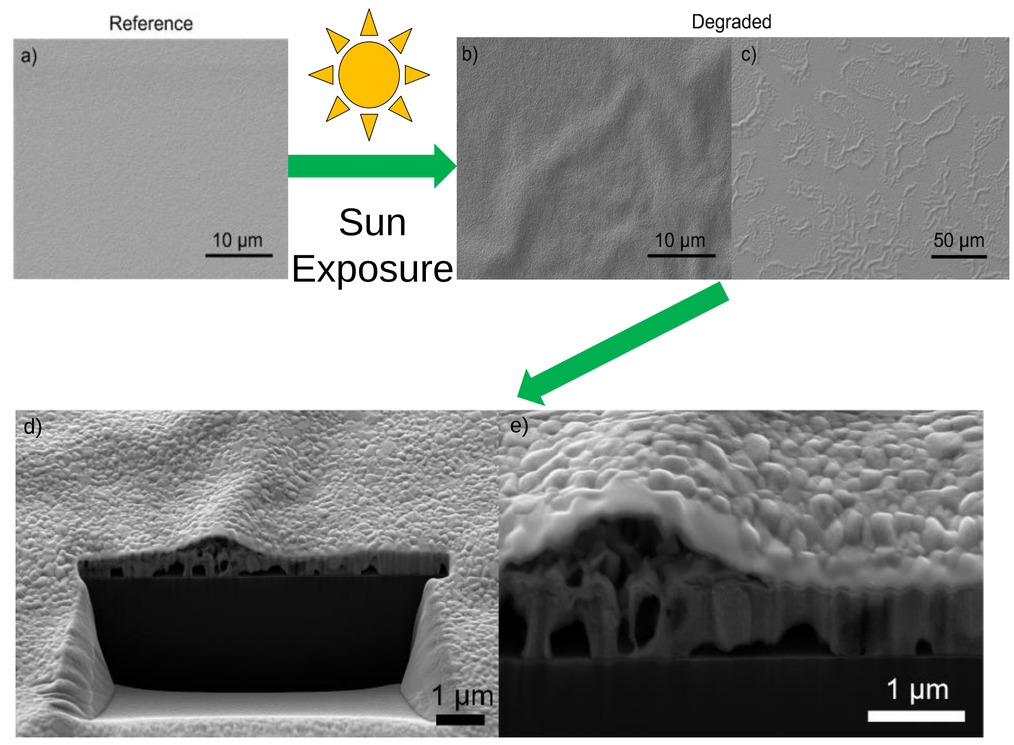

Fig. 4 | (a) SEM image of the sample's surface before exposing to Sun. (b), (c), (d) and (e) SEM images after 5 weeks of sun exposure. (b) and (c) are surface images, (d) and (e) are images taken after FIB milling, exposing the layers underneath.

Conclusions

- Different grain sizes have been obtained in the two different types of perovskite devices. Larger grain sizes have been obtained in perovskite type B.
- Type B perovskite-based devices exhibits approximately 1.4 higher current densities than type A perovskites.
- In Ultrafast spectroscopy measurements the main characteristics of the differential transmission curve (position of the main peak and differential transmission amplitude) show little changes with degradation.
- Decay constants of the differential transmission curves revealed increase in relaxation times attributed to perovskite compositional changes.

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