Stability enhancement by controlling the α/δ phase of Formamidinium lead triiodide thin films

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Introduction

Hybrid perovskites solar cells have experienced a significant improvement in efficiency during these last few years, the power conversion efficiency (PCE) has amplified from 3.8% in 2009 to over 25% in 2019 [1] and still a window for researchers to improve the (PCE) in the future specially the Perovskites have flexibility for chemical substitution.

In this context to control the stability of the desired α-FAPbIβ and undesired δ-FAPbI, we investigate the effect of [(NH3)2C]⁺ (guanidinium, 278 pm) cation by substituted the [CH(NH2)3]⁺ (Formamidinium, 253 pm) cation in order to improve the structural, morphological and optical properties of FAPbIδ in order to control degradation and improve the stability of perovskite-based FAPbI solar cells. otherwise, the challenges and prospects for the stability of PSC based FAxGA1−xPbIy.

Absorber manufacture

The thin film was elaborated on FTO substrates of sizes 2 × 2cm. The substrates were carefully cleaned with acetone during 15 min and isopropanol during 15 min under ultra-sons, and finally with UV-ozone for 15 min. Then, to make the perovskite precursor solution, FAI (1M), PbI2 (1.05M), GAI (0.2M) were first dissolved in DMF and DMSO solutions for one hour. After the solution mixed at room temperature at 80°C for two hours in a glovebox after filtered with a 0.4μm (PTFE) filter. Then 50 μl of the prepared solution was dropped on the substrate and spin-coated at 2000 rpm for 10 seconds, then at 5000 rpm for 50 seconds 1 ml. of chlorobenzene was dropped on the perovskite films. The layers were treated at 220°C.

![Figure 1](preparation of FAPbI3 thin films by spin coating)

Results and Discussion

![Figure 2](XRD patterns of perovskite films x% GA: FAPbI, Full width at half maximum (FWHM) of peaks (110) α-FAPbI and (010) δ-FAPbI, Crystal structure of the α and δ FAPbI phases)

The structural properties of x% GA: FAPbI was systematically identified with different guanidinium content (0%, 2.5%, 5%, 10%, 20%). The FAPbI films diffractogram shows characteristic perovskite peaks of α-FAPbI; (110), (220) located at 14.00°, 28.13°, respectively but also show characteristic peak (010) of δ-FAPbI located at 11.8 (Figure 1a). The addition of 2.5% GA decreases the (010) peak intensity, indicating the coexistence of the two perovskite phases. After adding 10% GA, the α -FAPbI phase becomes predominant and the (010) almost disappears.

![Figure 3](a) X-ray diffractograms FAPbI, before and after 2 weeks (b) PL of FAPbI, before and after 2 weeks X-ray (c) X-ray diffractograms 10% GA: FAPbI, before and after 2 weeks (d) PL of 10% GA: FAPbI, before and after 2 weeks

The very slow degradation of 10% GA: FAPbI sample is studied by the UV-Vis spectroscopy. Figure 9 shows a slow diminution in the absorbance edge of 10% GA: FAPbI at humid environment. This evolution is correlated with a color change of the films color for dark brown to orange brown after two weeks as shown in photographs.

![Figure 4](FESEM of FAPbI3 and 10% GA: FAPbI before and after 2 weeks)

![Figure 5](Absorbance spectra of 10% GA: FAPbI3 the perovskite thin films before (fresh), after ageing for 1 day, 2 days, 2 Weeks at 60% RH and Photograph of 10% GA: FAPbI3 perovskite thin films fresh and aged 1 day, 2 days, 1 week, 2 weeks.

Conclusion

In this work, we have investigated the effect of GA incorporation into FAPbI3 lattice on the control of the α/δ phases. Our results show that a small amount of 10% GA, can hugely improve the morphology of the FAPbI3 film and slow down the degradation rate in humid areas. GA films exhibit smooth and homogeneous surface coverage with clear boundaries and no pinholes. XRD results indicated that the presence of GA enhances the growth of the α cubic black phase. The presence of GA has shown to slow down the degradation rate by preventing the formation of δ-FAPbI3 phase and PbI2 compounds.

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