Hybrid Perovskite Solar Cells

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Abstract

Recent advances in the efficiency of hybrid perovskite solar cells have motivated extensive research aimed at increasing stability with respect to humidity and light. It is known that altering the chemistry of the perovskite crystal can alter the lattice structure, and in turn, the stability. In order to fabricate more stable methylammonium lead iodide (MAPbI$_3$) cells, a series of precursor solutions was created by substituting increasing amounts of thiocyanate (SCN) for iodide (II) iodide (MAPbI$_3$). While no working devices were fabricated due to the suspected decomposition of the p-type layer, X-ray diffractometry was ultimately used to characterize the changes in the crystal lattices.

Methods

Fabrication:
- Ambient humidity conditions
- Substrate cleaning: ○ sonicated in acetone ○ ozone/UV (improve coverage)
- Spin-coating:
  - p-type: nickel oxide
  - MAPbI$_{3-x}$(SCN)$_x$ (SCN)
  - Solvent: dimethylformamide
  - Chlorobenzene quench
- Spin-coating: ○ MAPbI$_3$
  - p-type: PCBM (phenyl C$_6$-butyric acid methyl ester)

- Sputter-coated Al electrodes
- Instrument: AJA Orion 5
- Characterization:
  - SEM
  - Instrument: FEI Teneo
  - XRD
  - Instrument: Rigaku Miniflex 600
  - Software: GSAS-II

Results

Cells were fabricated with the perovskite layer then characterized initially with scanning electron microscopy (SEM). Changes in the uniformity of coverage as the amount of SCN increased are shown below. It is clear that for $x > 0.8$, a different crystal structure forms. The figures below are paired as unmagnified optical pictures and SEM images.

Notes:
A: highly reflective surface, pure PbI$_2$ precursor
B: apart from impurities, the surface appears very uniform
C: very thin layer of a new phase (red)
D: evidence of different crystal structure and poor coverage

Conclusions

For lower concentrations of SCN in precursor solutions, the resulting perovskite phases seem to be mostly tetragonal, as in the base case of $x = 0.0$ where pure MAPbI$_3$ formed. Future work should aim to relate the SCN concentration to the stability of working devices, which could seed a model used to predict the effects of other anion substitutions. Furthermore, comparisons of the stability of devices made in controlled humidity should be made.

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References