Research Center for Photovoltaics

$MAPbI_3$ Perovskite Solar Cells Fabricated by Low-Temperature Reaction of Iodine (I_2) with MAI and Pb Layered Films

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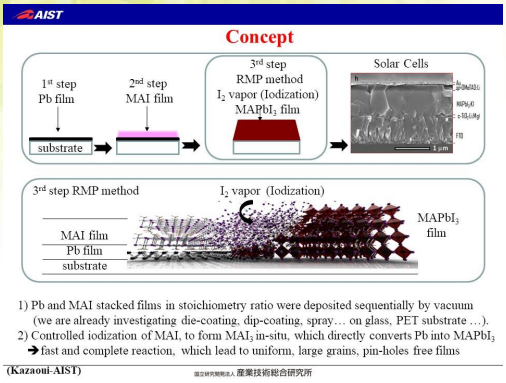
Introduction

The demand for new methods to reduce the manufacturing cost and to increase the efficiency has triggered our interest to study the Perovskite absorbers layers and solar cells fabricated by a novel "reactive polyiodide melt" (RPM) method, which was jointly developed by an international team including AIST/CEREBA and MSU/EPFL.

Goals

We will describe the "reactive polyiodide melt" (RPM) method and characterize the absorber layers fabricated by this method.
We will fabricate and characterize Perovskite solar cells.
We will demonstrate that this method is suitable for the fabrication of large area PVs.

Concept and Method



1) Pb and MAI stacked films in stoichiometry ratio were deposited sequentially by vacuum (we are already investigating die-coating, dip-coating, spray… on glass, PET substrate …).
2) Controlled iodization of MAI, to form MAI_3 in-situ, which directly converts Pb into $MAPbI_3$
➔ fast and complete reaction, which lead to uniform, large grains, pin-holes free films

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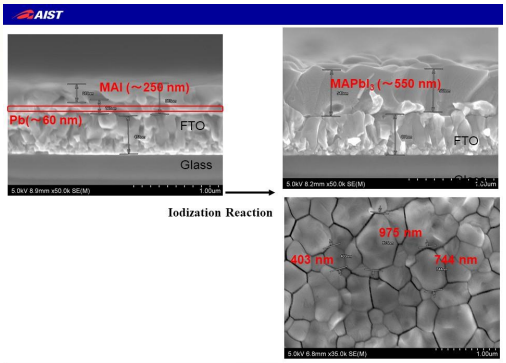

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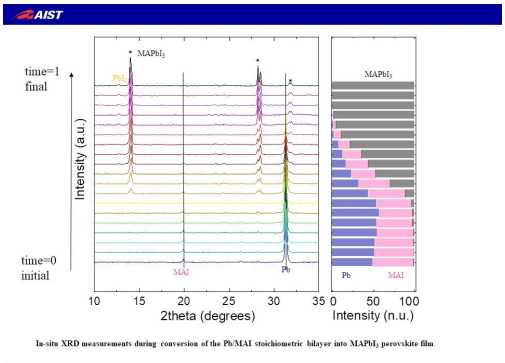

In-situ XRD measurements during conversion of the Pb/MAI stoichiometric bilayer into $MAPbI_3$ perovskite film.

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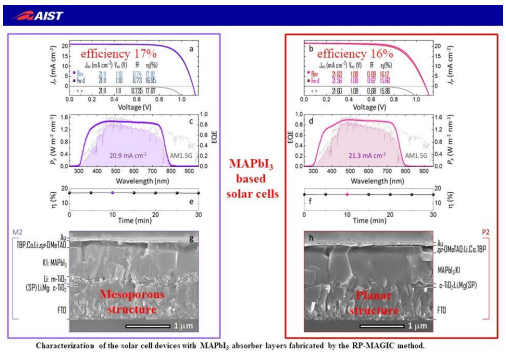
$MAPbI_3$ and (Cs,FA,MA)PbI_3 perovskite PVs



Characterization of the solar cell devices with $MAPbI_3$ absorber layers fabricated by the RP-MAGIC method.

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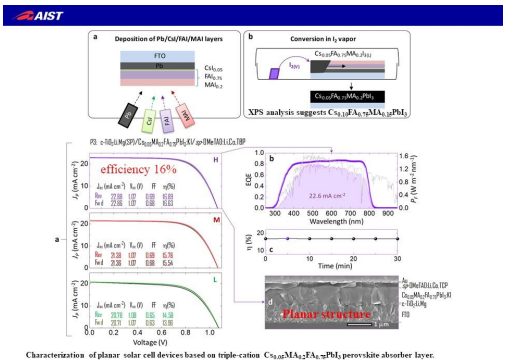

Characterization of planar solar cell devices based on triple-cation $Cs_{0.05}MA_{0.2}FA_{0.75}PbI_3$ perovskite absorber layer.

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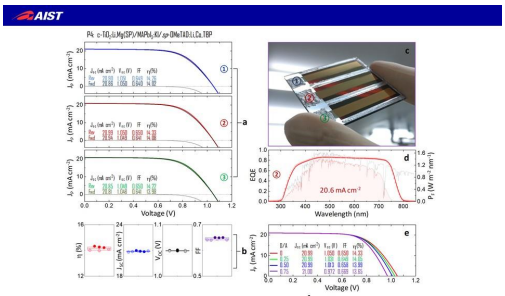

Characterization of relatively large area P4 planar 35x7=245 mm^2 solar cell based on $MAPbI_3$ absorber
Scaling up from 2x2=4 mm^2 to 35x7=245 mm^2 solar cell, the efficiency drop only by 3%, because mainly FF decreases and series resistance increases.

Next step: Fabrication of mini-modules.

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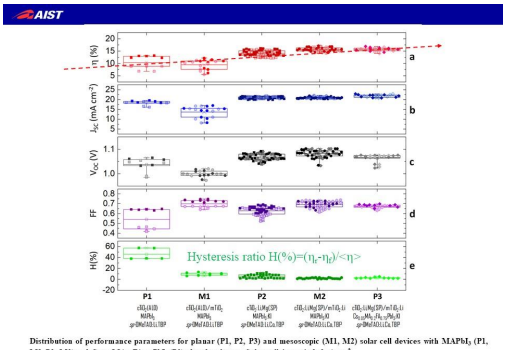

Distribution of performance parameters for planar (P1, P2, P3) and mesoscopic (M1, M2) solar cell devices with $MAPbI_3$ (P1, M1, P2, M2) and $Cs_{0.05}MA_{0.2}FA_{0.75}PbI_3$ (P3) absorber layers. Solar cells' area is 2x2=4 mm^2

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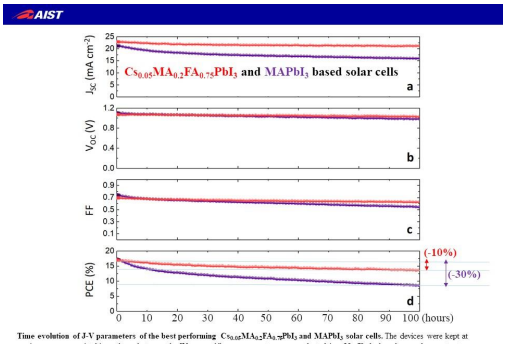

Time evolution of J-V parameters of the best performing $Cs_{0.05}MA_{0.2}FA_{0.75}PbI_3$ and $MAPbI_3$ solar cells. The devices were kept at maximum power point bias voltage between the IV scans. All measurements were conducted in a N_2-filled glove-box under constant simulated AM1.5G light (Newport LSH-7320) without temperature control.

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$MAPbI_3$ hybrid perovskite film fabricated by the RP-MAGIC method on glass and PET substrate.
Next task is the fabrication of large area and mini-module PVs.

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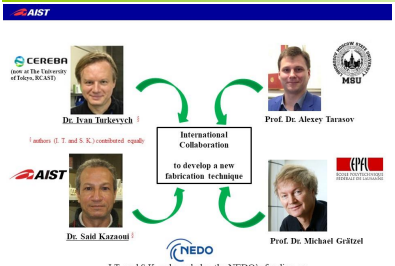
Conclusions

The originality of our novel "reactive polyiodide melts" method :

- **Near room temperature (25~60 °C), solvent-free and adduct-free formation of perovskite films exhibiting excellent quality over large areas.**
- **Applicability to the fabrication of $MAPbI_3$ and $Cs_{0.05}MA_{0.2}FA_{0.75}PbI_3$ perovskite thin films with various compositions in a highly controllable manner.**
- **Solar cells with reverse scan power conversion efficiencies of 16.12 % (planar $MAPbI_3$), 17.18 % (mesoscopic $MAPbI_3$), 16.89 % (planar $Cs_{0.05}MA_{0.2}FA_{0.75}PbI_3$) in the standard n-i-p FTO/c(m)-TiO_2/Perovskite/Spiro-OMeTAD/Au architectures can be fabricated.**
- **The scalability of this novel approach by producing uniform $MAPbI_3$ films on large 100 cm^2 glass/FTO and flexible 600 cm^2 PET/ITO substrates.**

Acknowledgements



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References:
[1] "A new formation strategy of hybrid perovskites via room temperature reactive polyiodide melts"
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[2] "Strategic advantages of reactive polyiodide melts for scalable perovskite photovoltaics"
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