

High Stability and High Efficiency Perovskite Solar Cells

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Introduction

The demand for new materials in order to increase the efficiency and to reduce the cost has triggered our interest to study the "Organo-Lead Halide Perovskite" solar cells.

Goals

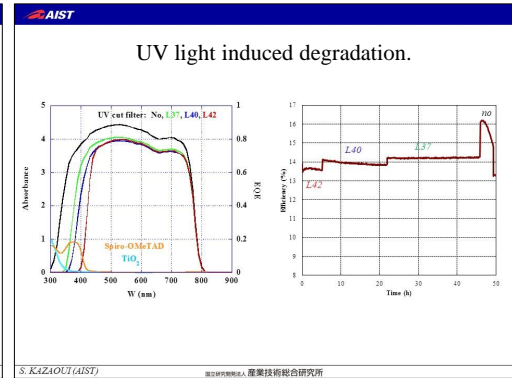
We compare the efficiency and the stability of MAPbI₃ and (Cs,FA,MA)Pb(I,Br)₃ Perovskite solar cells fabricated by wet solution process. MA is methylammonium (CH₃NH₃⁺) and FA is formamidinium (HN=CHNH₃⁺) cations.

Methods

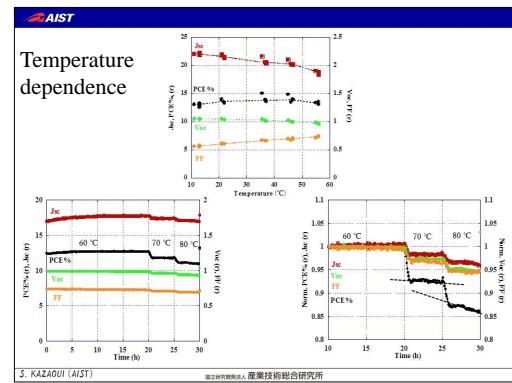
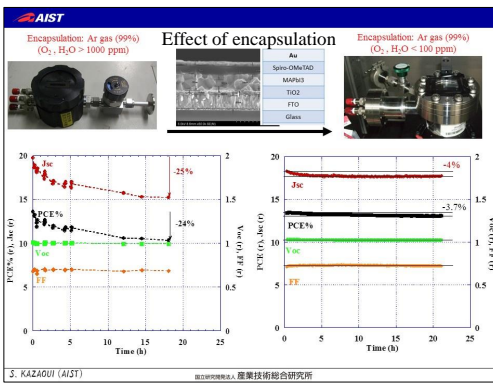
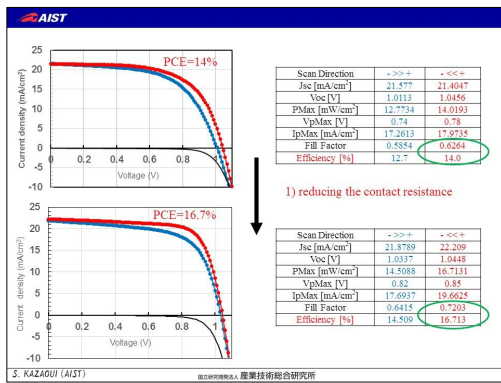
	Parameters
FTO/Glass substrate	FTO (TEC7, TEC15) patterned by etching with Zn+HCl or sand blasting; Hallmaxes 2%, Rinsed with DI water, acetone, 2-propanol O ₂ plasma (18 mW, 100 Pa, 15 min)
TiO ₂ layers	1) dense TiO ₂ made by PE-ALD at 300 °C, using RF O ₂ plasma and TTP (titanium tetrakis-isopropoxide). 2) porous TiO ₂ made using TiO ₂ paste (DSL18N-T) spin coated at 2000-4000 rpm, 30 s. Annealed at 120 °C/10 min then 450 °C/30 min in oven (flow dry air 1 L/min).
CH ₃ NH ₃ PbI ₃ layer	(MAI+PbI ₂) or (CH ₃ FAl+PbI ₂ +MABr ₂ +PbBr ₂) in DMSO/DME solution stirred at 25°C (1 L). spin coated in 2 steps 1000-6000 rpm, dripping the anti-solvent such as chlorobenzene, toluene or diethyl-ether. Annealed at 100 °C, ~1min in Ar/N ₂ glove-box (depending on the composition of the perovskite). Structure confirmed by XRD
Spiro-OMeTAD PFAA	Spiro-OMeTAD-chlorobenzene (Li-salt, TBP, Co, AN) solution spin-coated at 3000 rpm, 30 s in Ar/N ₂ glove-box
Au electrode	100 nm of Au deposition in THF 2 × 10 ⁻⁴ Pa, 1500 °C, 1-10 Ås ⁻¹ PV cell encapsulated in Ar/N ₂ glove-box

Methods:

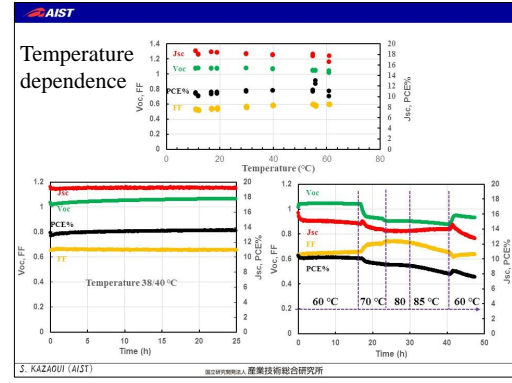
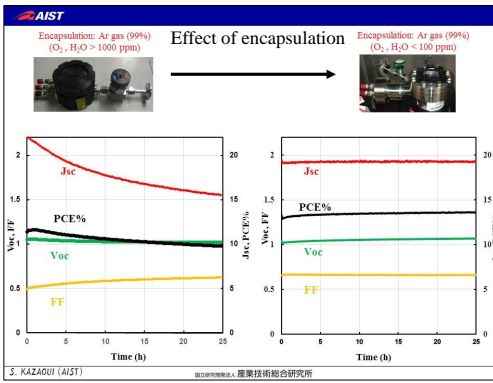
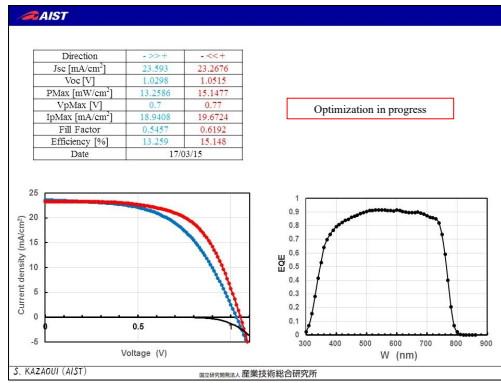
- Solar cells fabricated in Ar/N₂ gas glove-box (O₂/H₂O < 100 ppm)
- Encapsulated under Ar/N₂ gas (O₂/H₂O < 100 ppm)
- 1 sun continuous illumination (WACOM WXS-200S, 1 sun A.M. 1.5, 100 mW/cm², xenon lamp)
- UV cut filters (L-42, L-40, L-37), otherwise the degradation is very fast
- Constant temperature (25 ~ 85 °C) and humidity (RH < 15%, Hitachi EC-45HHP chamber)
- IV curves are scanned at 200 ms, step 0.01 V, range (-0.1 ~ 1.1 V), otherwise input bias is 0 V
- MPPT (maximum power point tracking, VK-PA-25 PV Power Analyzer SPD Lab.)
- EQE curves are recorded at 0 V, without white light bias (constant photon, Bunkoukeiki CEP3000)



MAPbI₃ perovskite PVs



(Cs,FA,MA)Pb(I,Br)₃ perovskite PVs



Conclusions / Perspectives

- Power conversion efficiency (PCE%) > 15% was achieved with both MAPbI₃ and (Cs,FA,MA)Pb(I,Br)₃ PVs. To achieve high efficiency the optimization of the chemical composition of (Cs,FA,MA)Pb(I,Br)₃ PVs is in progress.
- High stability is achieved for PVs fabricated and encapsulated in low level of O₂/H₂O < 100ppm (Ar glove box), but low stability for PVs fabricated in dry air (20% O₂, 5% RH) or encapsulated in high level O₂/H₂O > 1000 ppm.
- Both MAPbI₃ and (Cs,FA,MA)Pb(I,Br)₃ PVs show a relatively high thermal stability up to 60 °C, but poor thermal stability above 70/80 °C.

Experiments are in progress to elucidate the origin (perovskite, hole and electron transport layers) and the mechanisms leading to the degradation of PVs.

Acknowledgements:

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