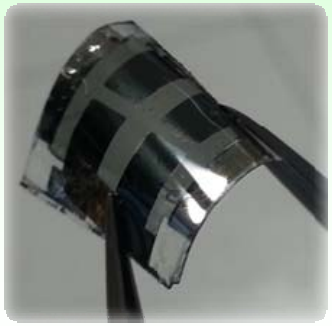
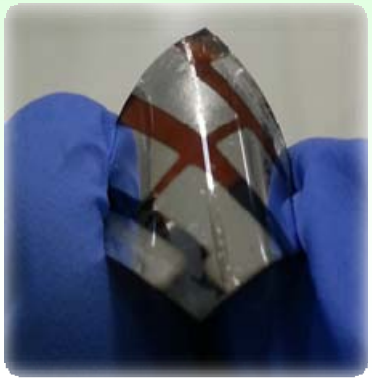
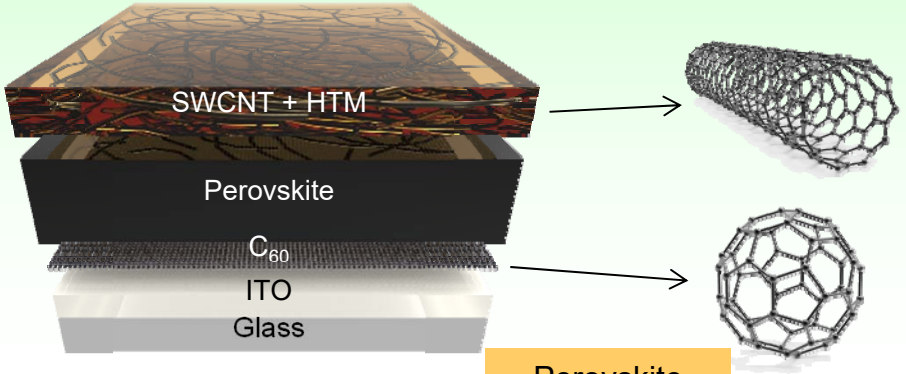
ナノカーボン材料を用いたペロブスカイト型太陽電池



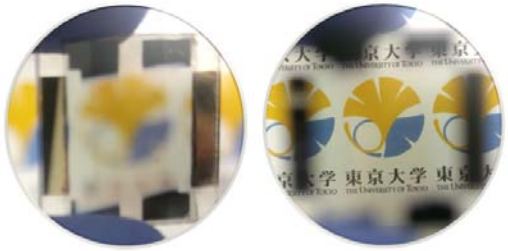
Organic Thin Film
(Normal)



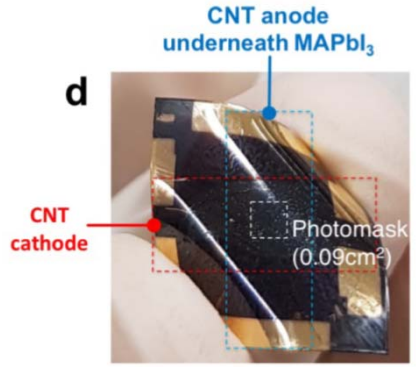
Perovskite
(Inverted)



Perovskite
(Normal)



Organic Thin Film
(Inverted)



Perovskite
CNT for Anode
and Cathode

Shigeo Maruyama（丸山 茂夫）
Department of Mechanical Engineering, The University of Tokyo
Energy NanoEngineering Lab., AIST
College of Chemistry and Molecular Engineering, Peking University

Acknowledgements

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Maruyama - Chiashi Laboratory

The University of Tokyo, Department of Mechanical Engineering

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Associate Prof.:
Shohei Chiashi
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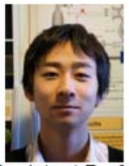
Assistant Prof.:
Xiang Rong
[xiangrong]



Assistant Prof.:
Taiki Inoue
[inoue]

Visiting Prof.:
Kazutomo Suenaga
[suenaga-kazu]

Visiting Prof.:
Yan Li
[yanli]

Visiting Prof.:
Yutaka Matsuo
[matsuo]

Project Assistant Prof.:
Jeon Il
[il.jeon]

Energy NanoEngineering Lab

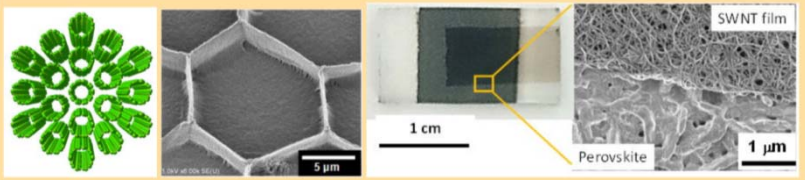
AIST
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Japanese Mode is here.

You are the 001449th visitor, since August 21, 2015

- Energy NanoEngineering Lab. Established on April 1, 2015
- Research Institute of Energy Conservation
- Department of Energy and Environment
- National Institute of Advanced Industrial Science and Technology (AIST)
- 1-2-1 Namiki, Tsukuba, 305-8564, Japan
- AIST Tsukuba East, Main Building (East-1B) 3F, Room 3103
- TEL:029-861-2073 (AIST internal:222-32073)

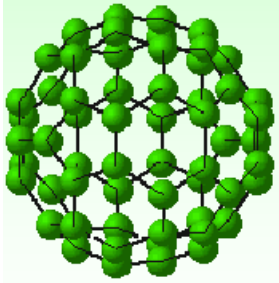
Research Direction:



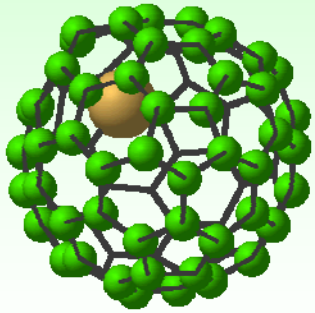
April 20, 2016

FNTG Research Society

Research Society



Fullerene



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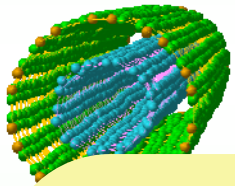
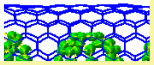




FI

1991: C60 Research Associ
1991: *President: Professor*
1995: The Fullerenes Rese
2002: The Fullerene Nanot
2003: *President: Professor Hi*
2005: The Fullerenes and Nanotubes Research Society
2011: The Fullerenes, Nanotubes and Graphene Research Society
2011: *President: Professor Shigeo Maruyama (UTokyo)*

Meetings

2017/3/1-3: FNTG 52 Symp. @ Tokyo
2017/6/25-30: NT17 @ Brazil
2017/9/13-15: FNTG 53 Symp. @ Kyoto

2018/3/10-12: FNTG 54 Symp. @Tokyo
2018/7/8-12: WONTON2018 @ Hakone
2018/7/15-20: NT18 @ Beijing
2018/9/11-13: FNTG 55 Symp. @ Sendai

2019/2/??-??: FNTG 56 Symp. @ Tokyo
2019/7/21-26: NT19 @ Würzburg
2019/9/?-?: FNTG 57 Symp. @ Nagoya

...ond

IRENA

Indium **R**eplacement by **E**ngineered **N**anotube **A**ssemblies


S. Maruyama


E. I. Kauppinen


H. Shinohara

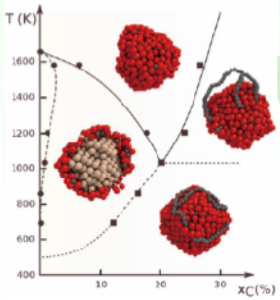

C. Bichara


Y. Ohno

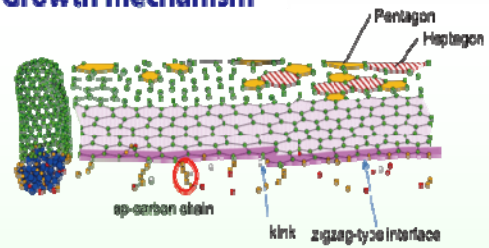

J. Wagner

Simulation techniques

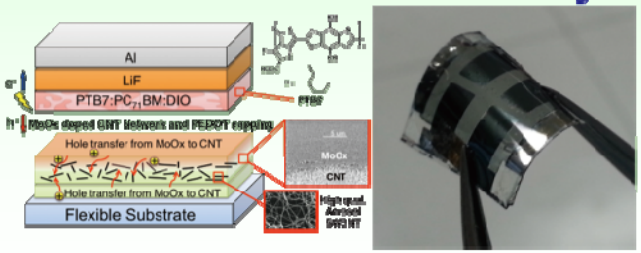
Role of catalyst



Growth mechanism



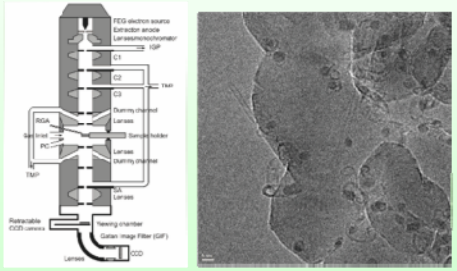
Flex organic solar cells



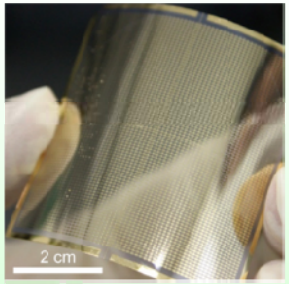
One-step transfer printing fabrication of touch sensors

State-of-the-art CNT Films & Device Technologies for Flex, 3D Electronics

In-situ TEM analysis



Large scale, rapid separation

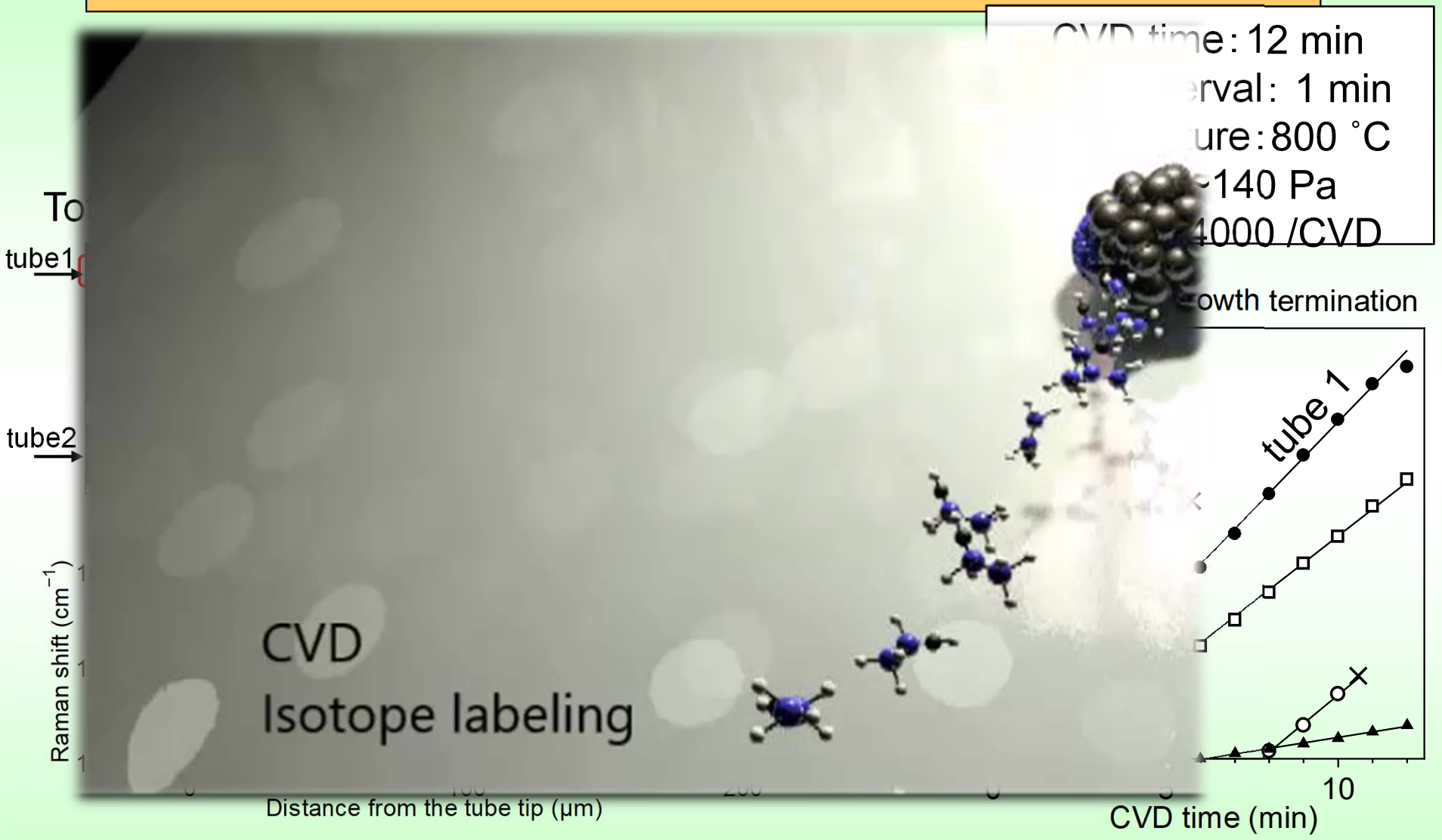


High-performance Flex TFTs

Partners:

Aix*Marseille université — cnrs — Technical University of Denmark — DTU — ONERA — NAGOYA UNIVERSITY — THE UNIVERSITY OF TOKYO

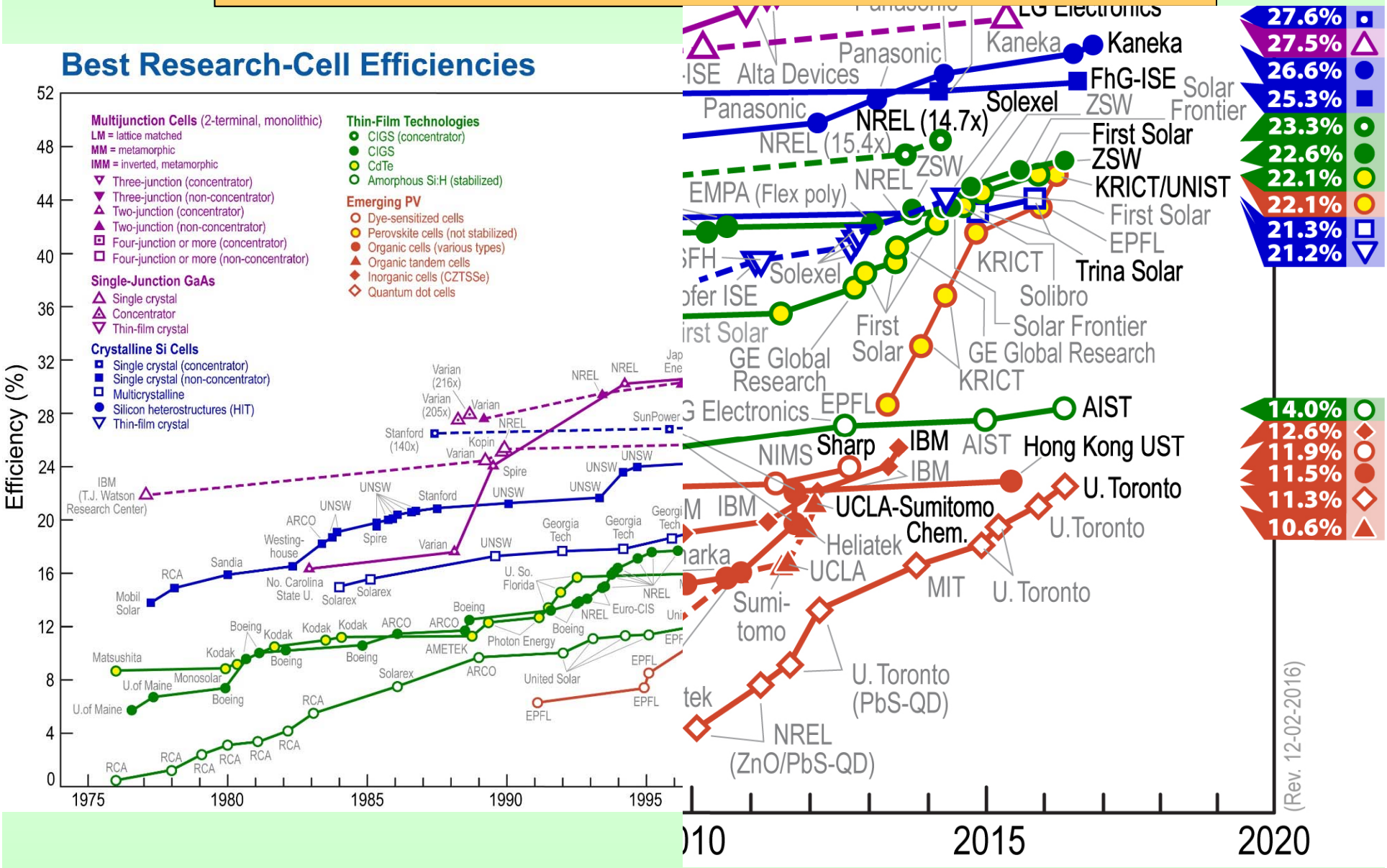
Time evolution of SWNT lengths



- Sudden stop of growth ($\Leftrightarrow L = \gamma\tau_0(\exp(-t/\tau_0)$ [1])
- Differen

K. Otsuka et al., ACS Nano (2018) [DOI: 10.1021/acsnano.8b01630]

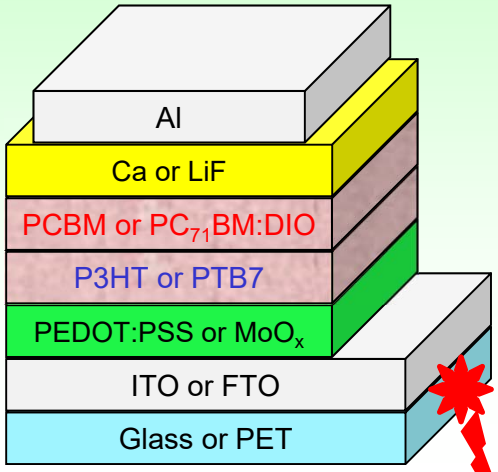
NREL solar cell efficiency chart



http://www.nrel.gov/ncpv/images/efficiency_chart.jpg

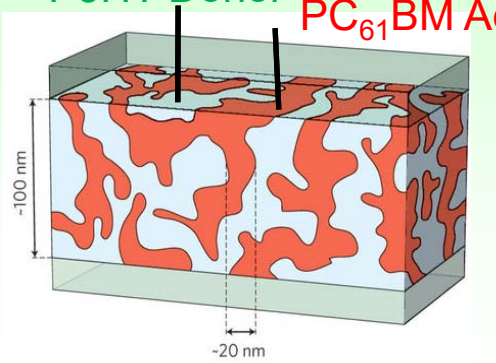
Organic Thin Film

Normal structure

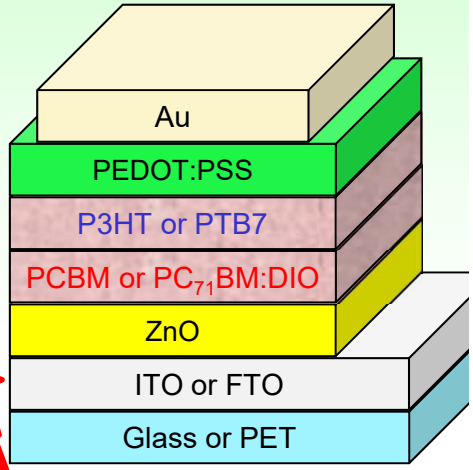


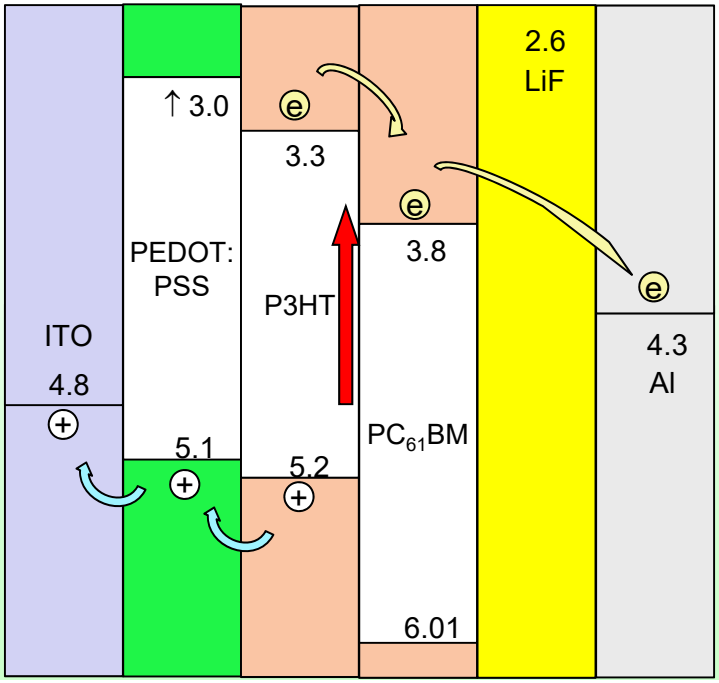
P3HT Donor

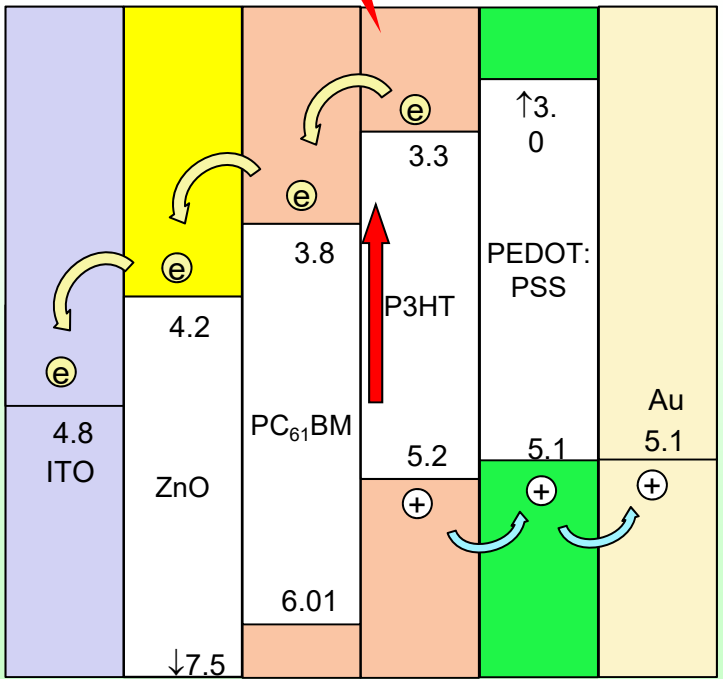
$PC_{61}BM$ Acceptor



Inverted structure

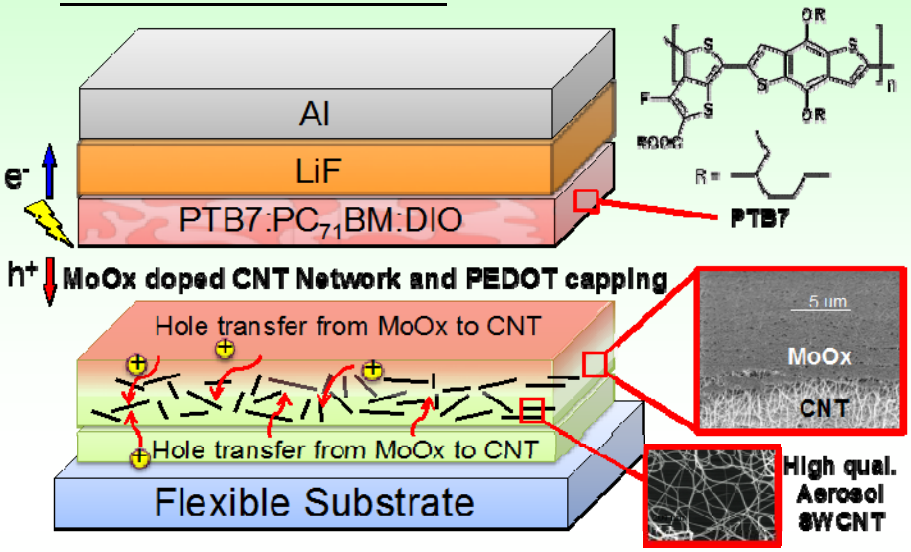




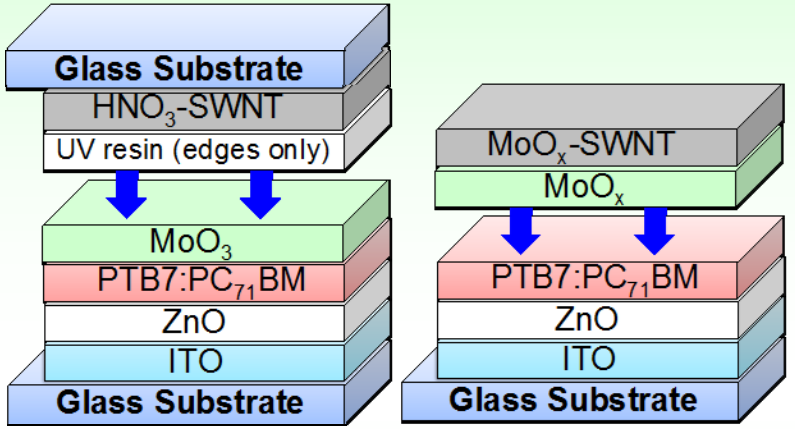


CNT for Organic Thin Film

Normal structure

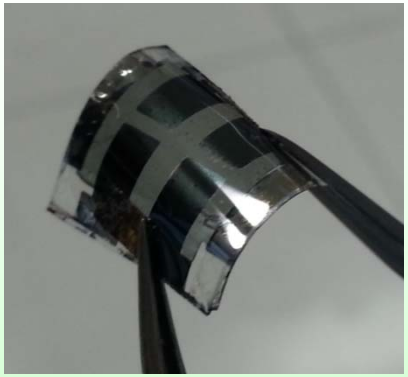


Inverted structure

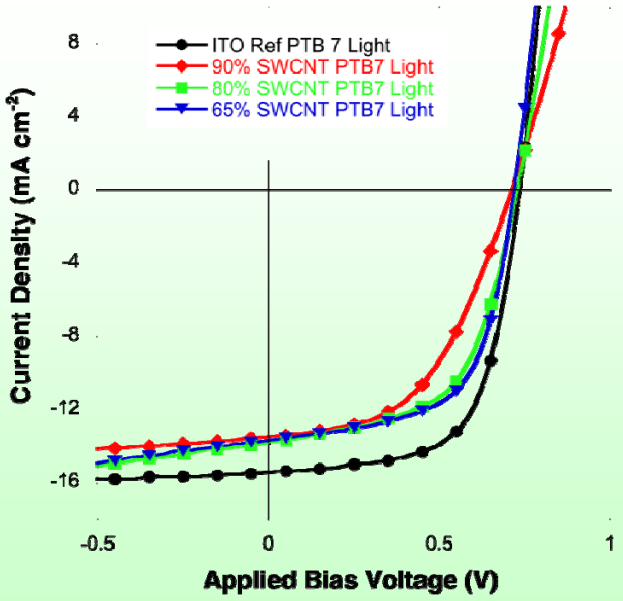


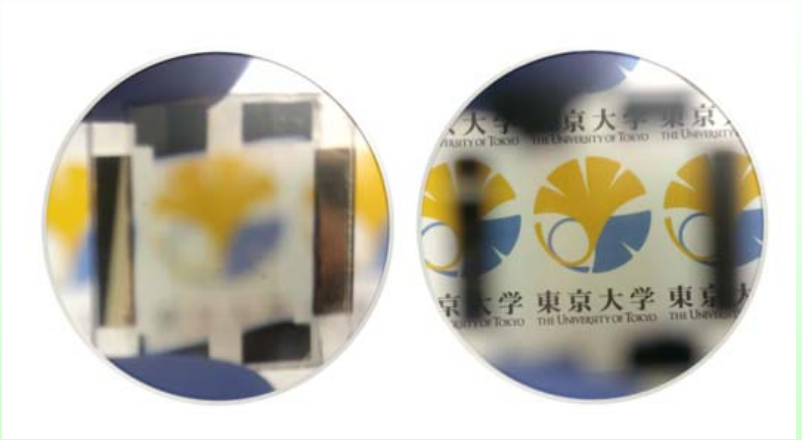
Sandwich HNO3:3.7 %

Bridge MoOx:3.1 %



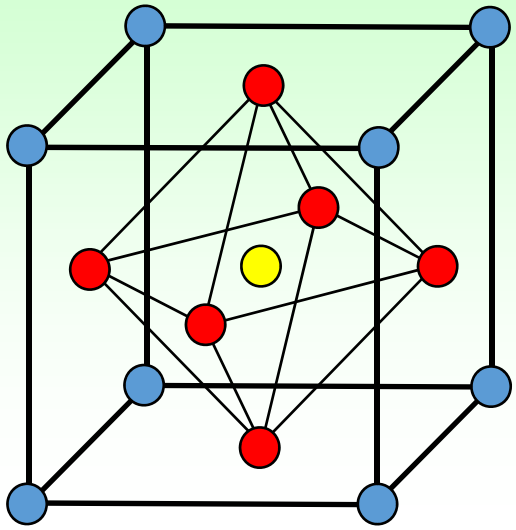
Il Jeon et al.,
JACS
137 (2015) 7982.





I. Jeon et al., Sci. Rep., 6 (2016) 31348.

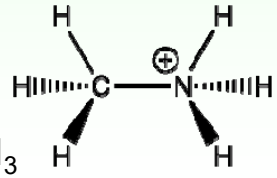
Perovskite Solar Cells



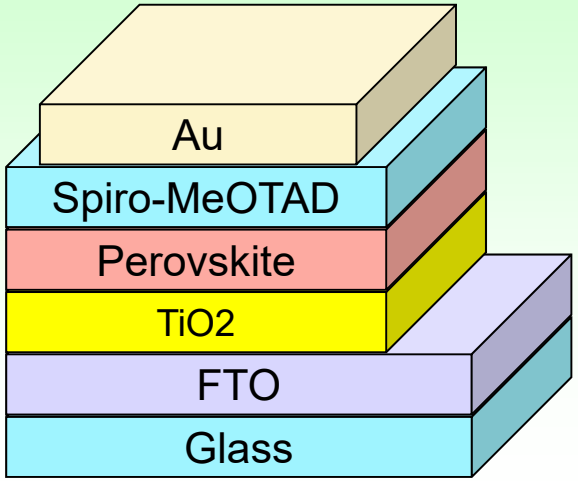
Perovskite: AMX_3

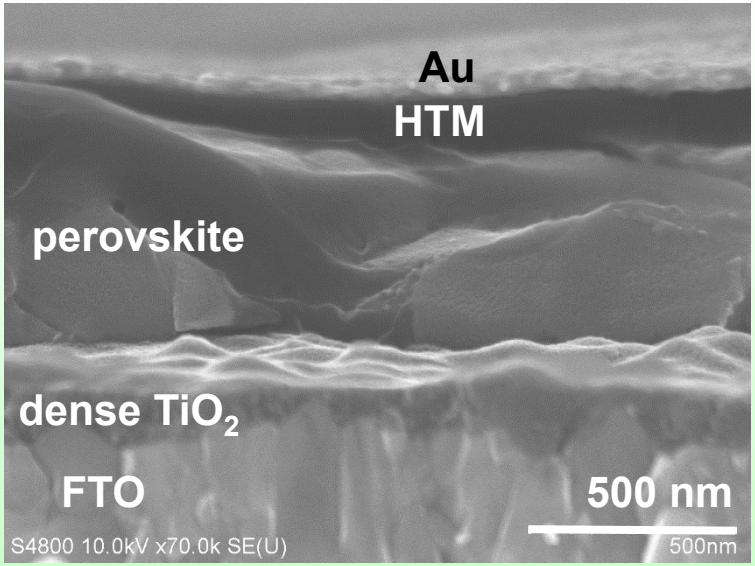
- A = Methylammonium (MA), $CH_3NH_3^+$
  Formamidinium (FA), $CH_3(NH_2)_2^+$
  Guanidinium (Gua), $CH_6N_3^+$
- M = Pb^{2+}, Sn^{2+}, Cs^{2+}, Rb^{2+}
- X = I^-, Cl^-, Br^-

$MAPbI_3$: $CH_3NH_3PbI_3$

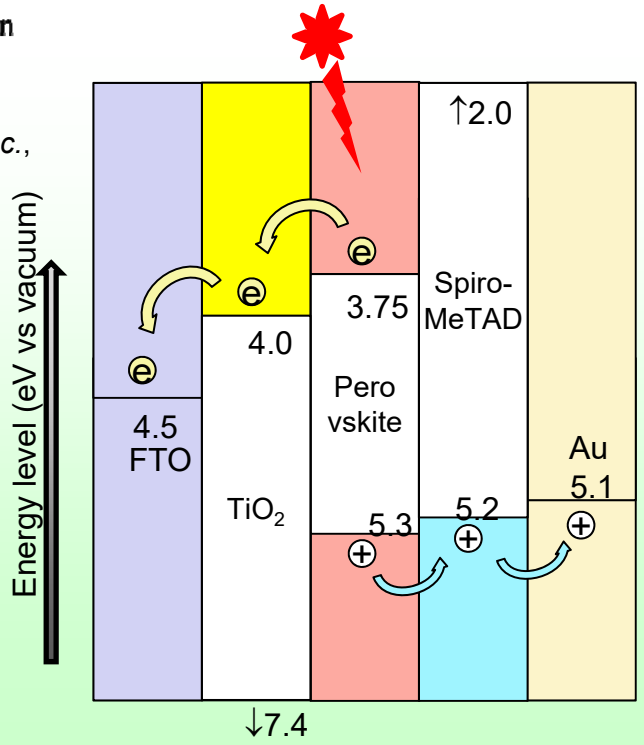


methylammonium ion

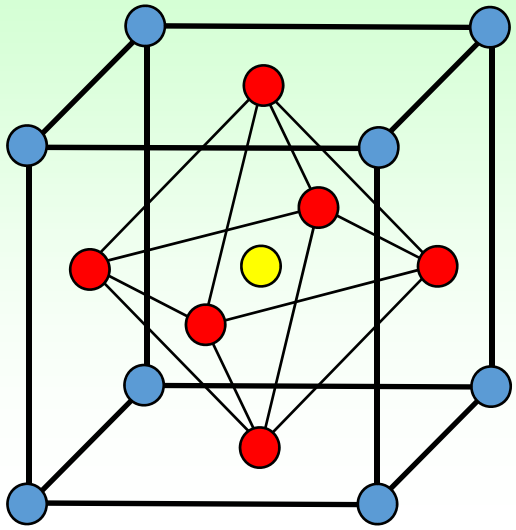




- Use of Perovskite **PCE 3.8 %**
  A. Kojima, *et al.*, *J. Am. Chem. Soc.*, **2009**
- Solid state solar cell **PCE 10.9 %**
  M. M. Lee, *et al.*, *Science*, **2012**
- High **PCE 20.1 %**
  N. J. Jeon, *et al.*, *Nature*, **2014**
- **PCE record 22.1% 2016**



Perovskite Solar Cells



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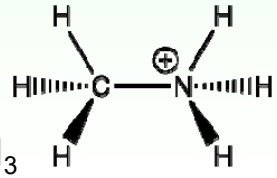
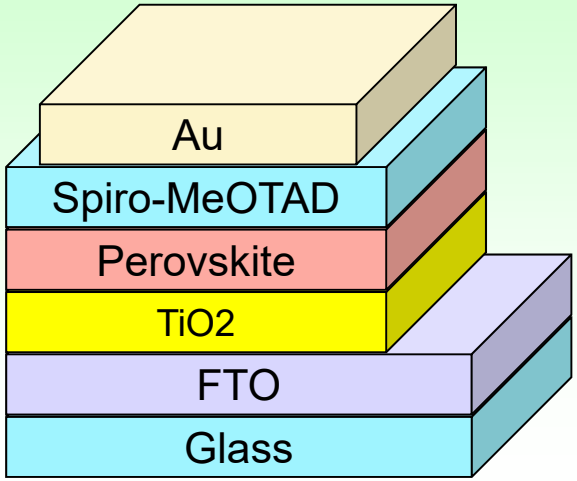
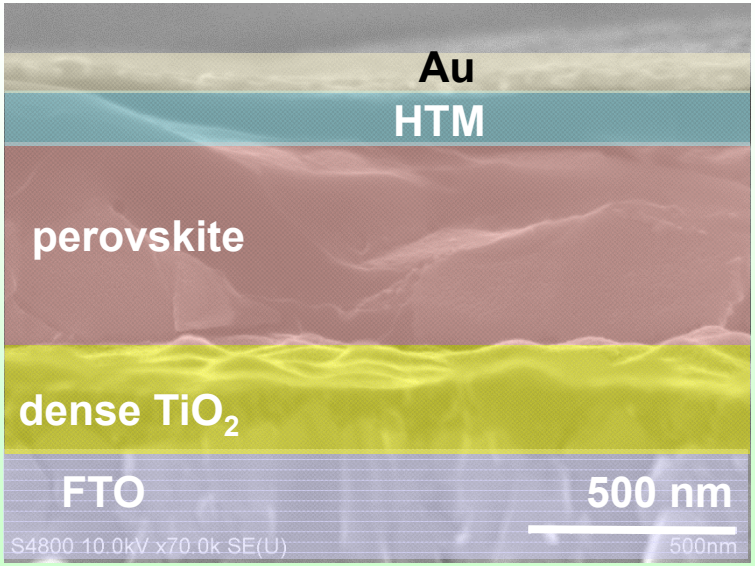


methylammonium ion





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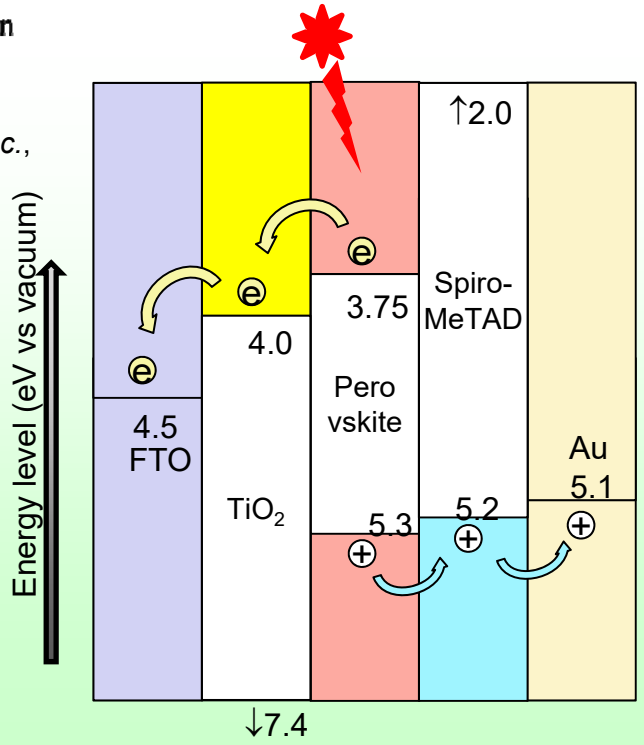
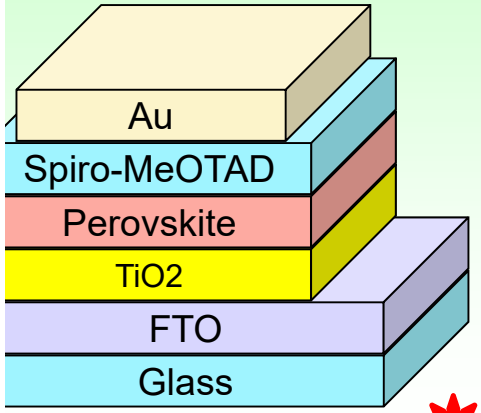
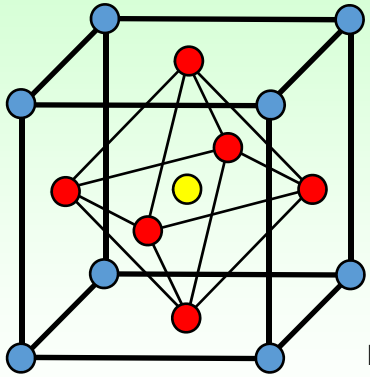


Organic-Inorganic Hybrid Perovskite Solar Cells

Normal structure





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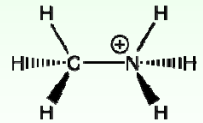
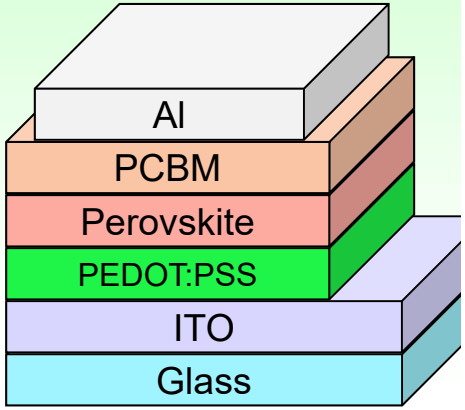
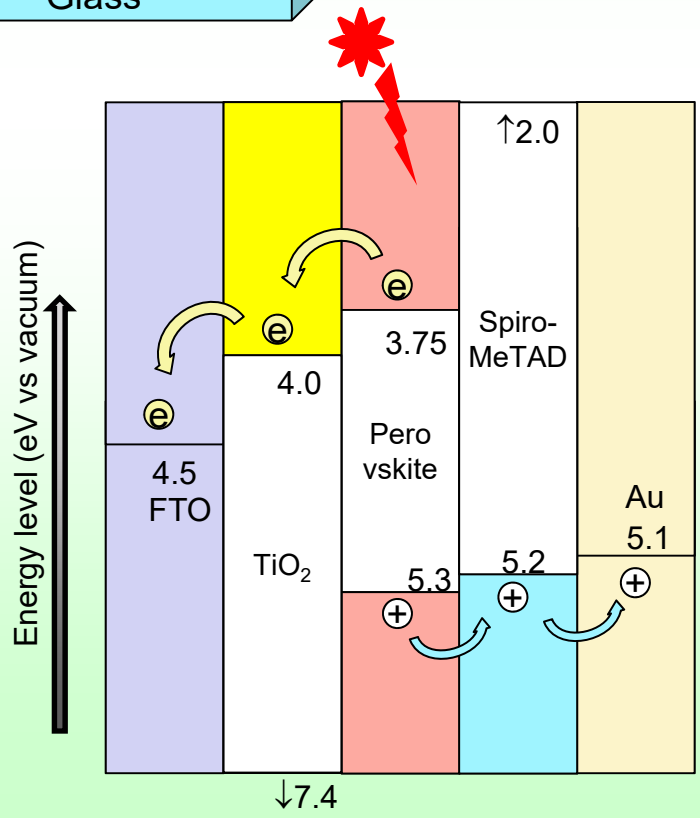
$MAPbI_3$: $CH_3NH_3PbI_3$

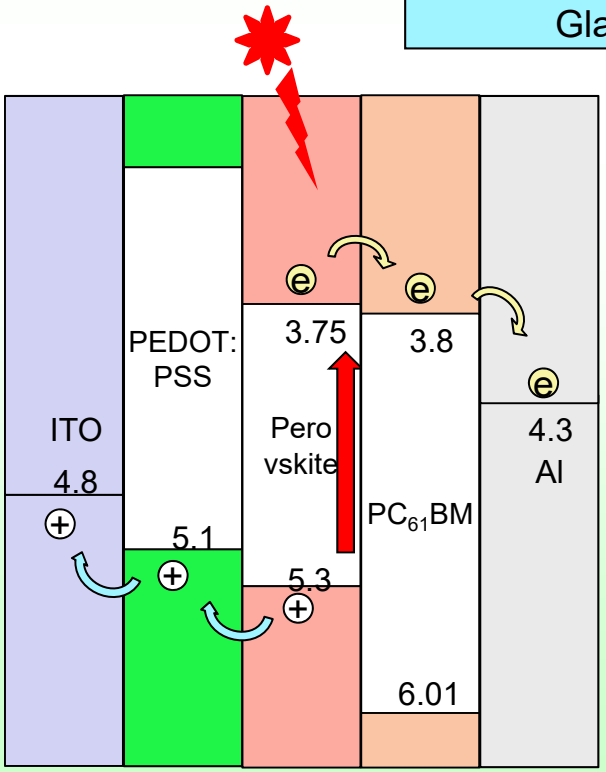


methylammonium ion

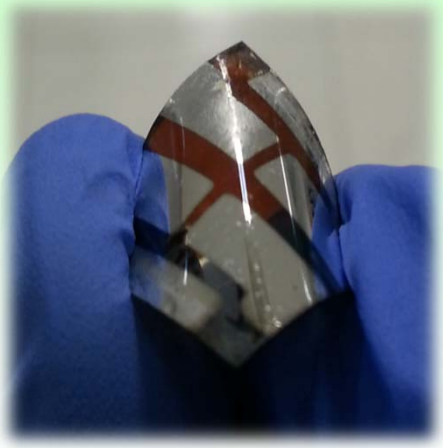
Inverted structure

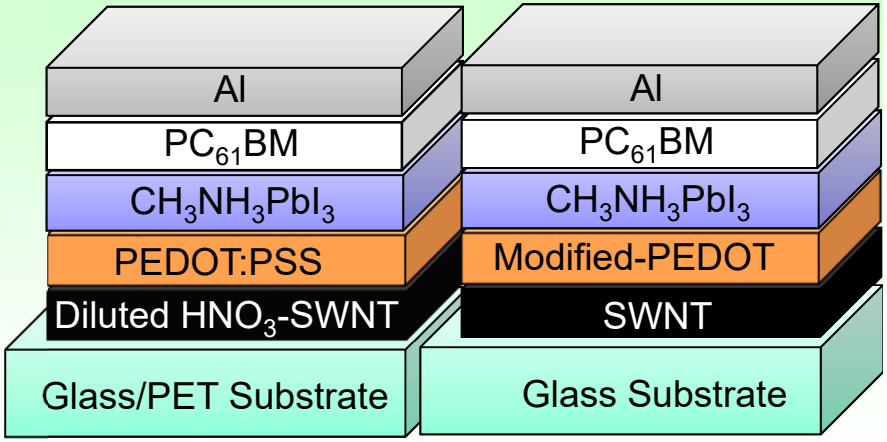


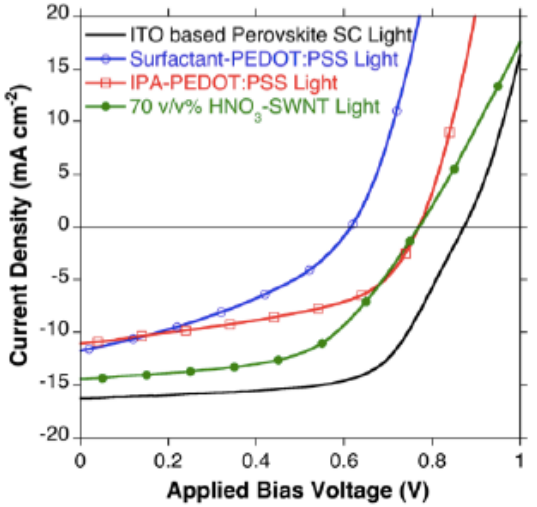




ITO-Free Perovskite Solar Cells



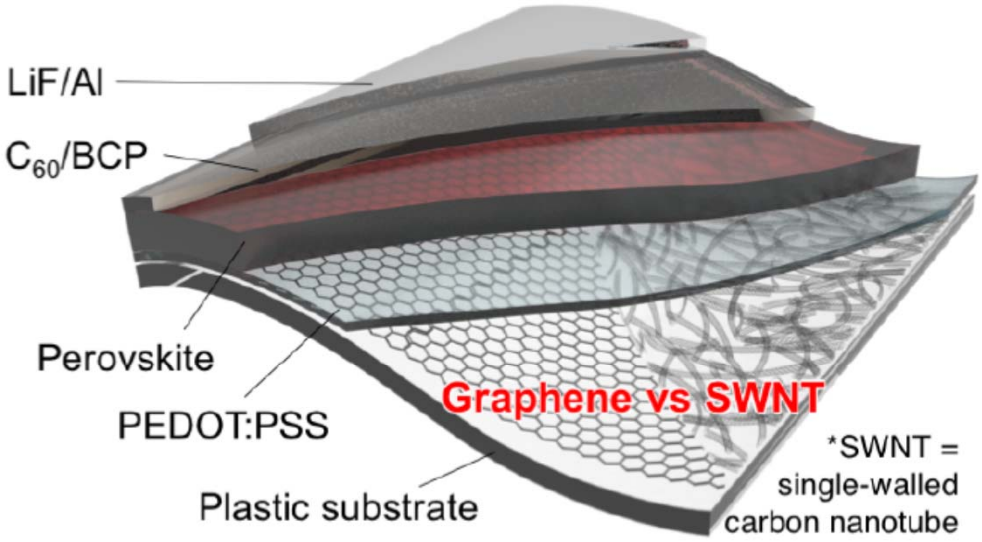




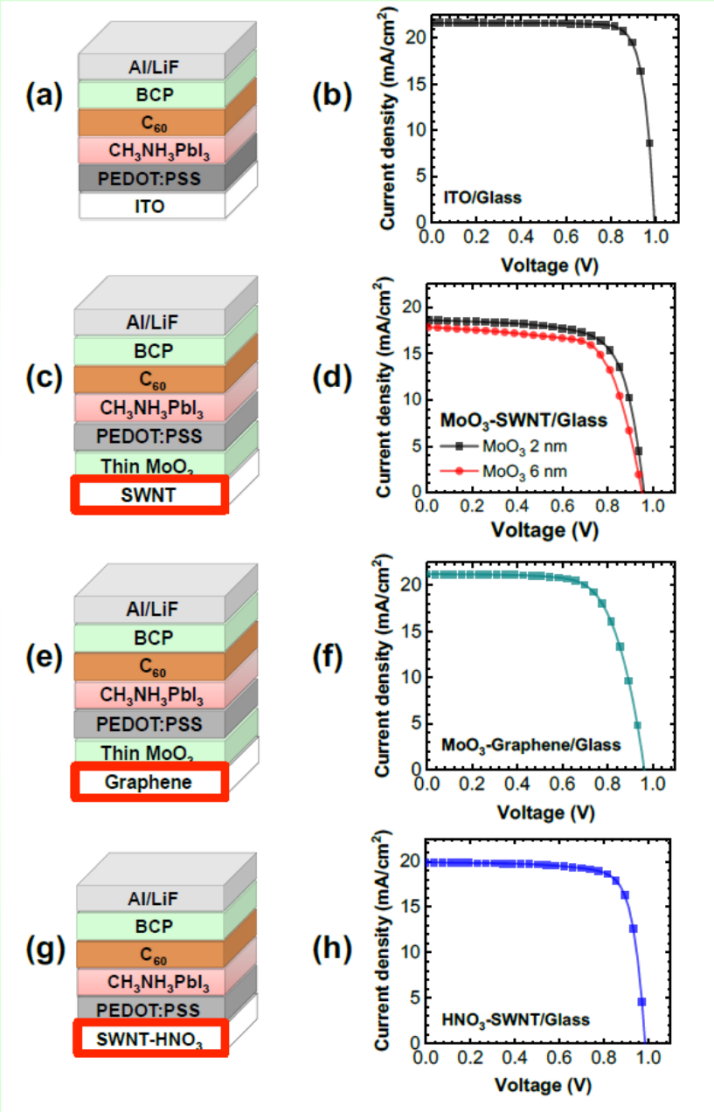
Substrate	Anode	HTL	V_{OC} (V)	J_{SC} (mA/cm^2)	FF	PCE (%)
Glass	ITO	PEDOT:PSS	0.83	16.3	0.64	9.05
Glass	SWNT	IPA-PEDOT:PSS	0.77	11.1	0.50	4.27
Glass	SWNT	Surfactant-PEDOT:PSS	0.61	11.8	0.38	2.71
Glass	70 v/v% HNO_3-SWNT	PEDOT:PSS	0.77	14.4	0.55	6.09
Glass	50 v/v% HNO_3-SWNT	PEDOT:PSS	0.76	14.5	0.52	5.84
Glass	35 v/v% HNO_3-SWNT	PEDOT:PSS	0.79	14.9	0.54	6.32
Glass	15 v/v% HNO_3-SWNT	PEDOT:PSS	0.77	13.6	0.39	3.88
PET	35 v/v% HNO_3-SWNT	PEDOT:PSS	0.71	11.80	0.56	5.38

I. Jeon, T. Chiba, C. Delacou, Y. Guo, A. Kaskela, O. Reynaud, E. I. Kauppinen, S. Maruyama, Y. Matsuo, *Nano Lett.,* 15 (2015) 6665.

Carbon nanotubes vs graphene for inverted PSC

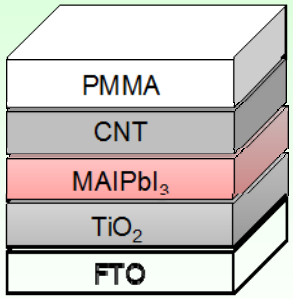


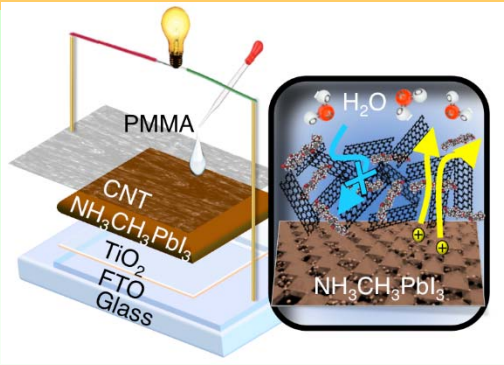
Efficiency	14.2%	12.8%
Reproducibility	moderate	high
Cyclic flexibility	flexible	very flexible

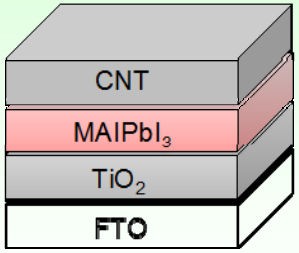


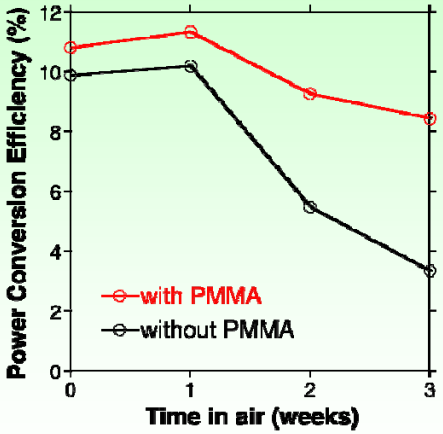
I. Jeon, J. Yoon, N. Ahn, M. Atwa, C. Delacou, A. Anisimov, E. Kauppinen, M. Choi, S. Maruyama, Y. Matsuo, J. Phys. Chem. Lett., 8 (2017) 5395.

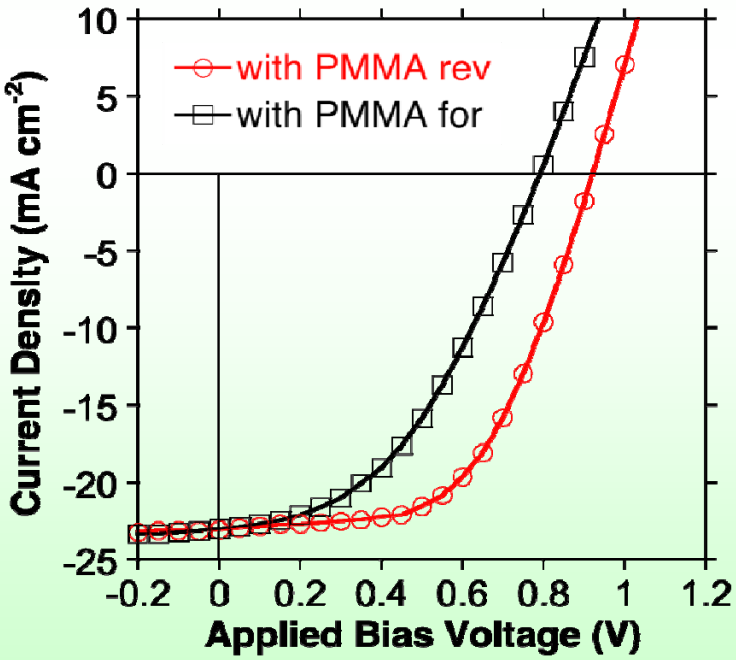
CNT Electrode (PMMA Layer for Stability)

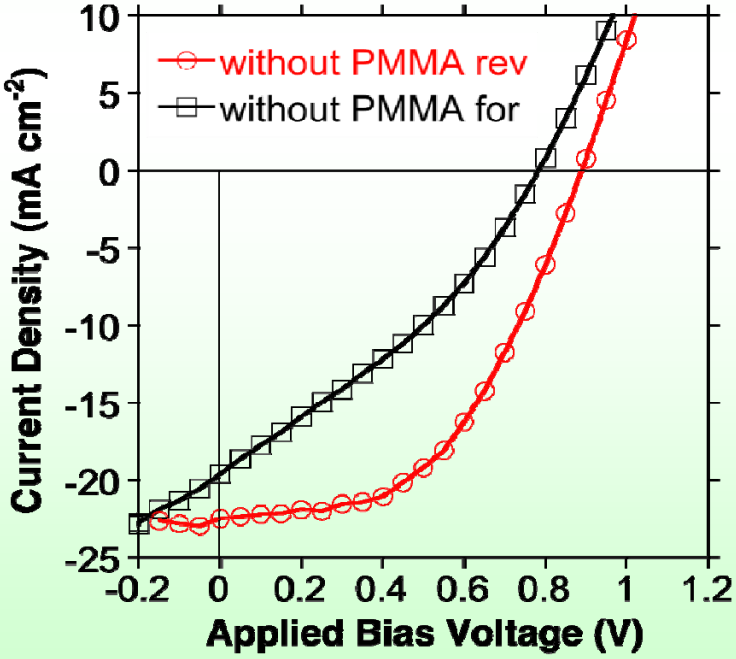






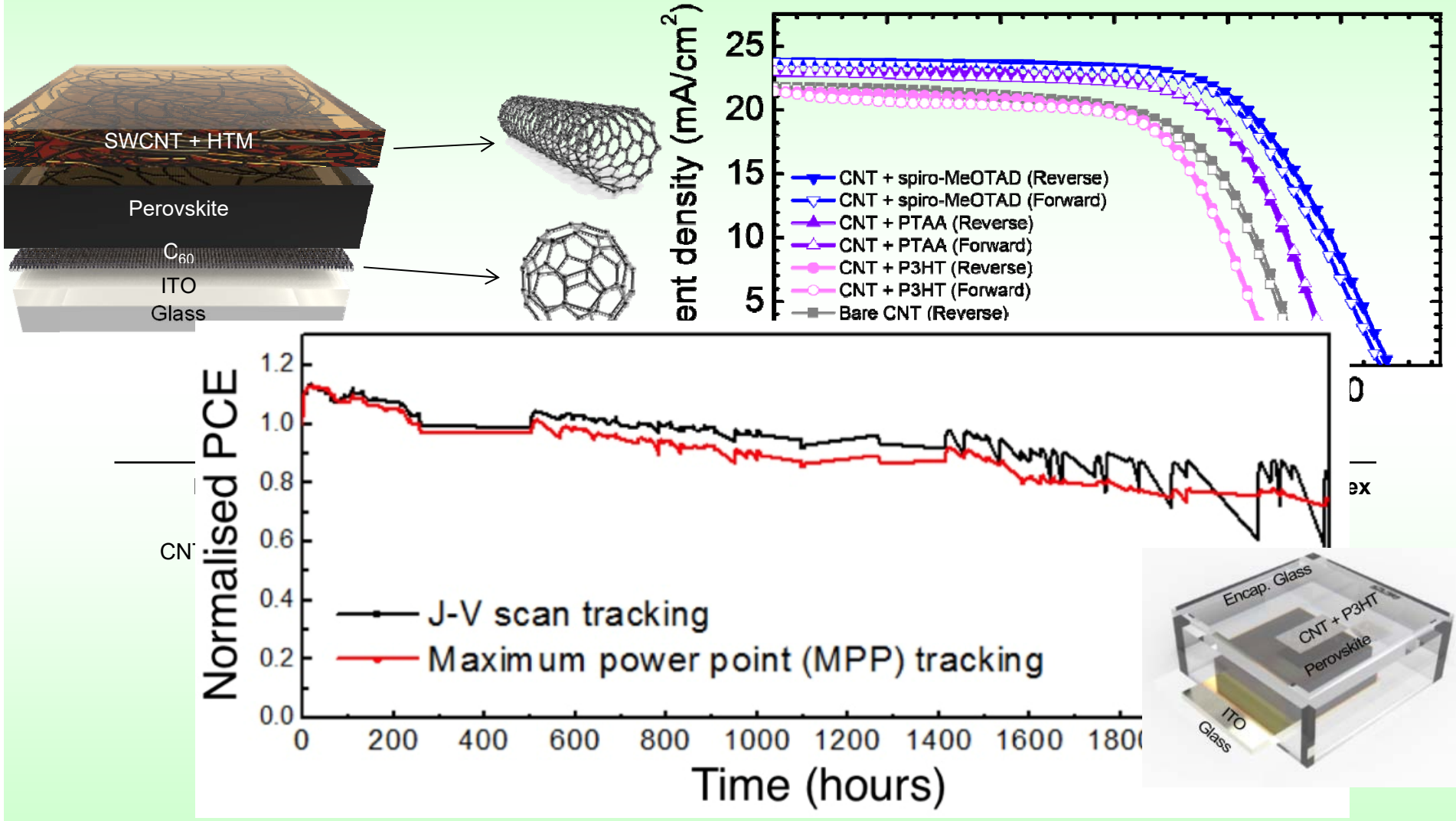






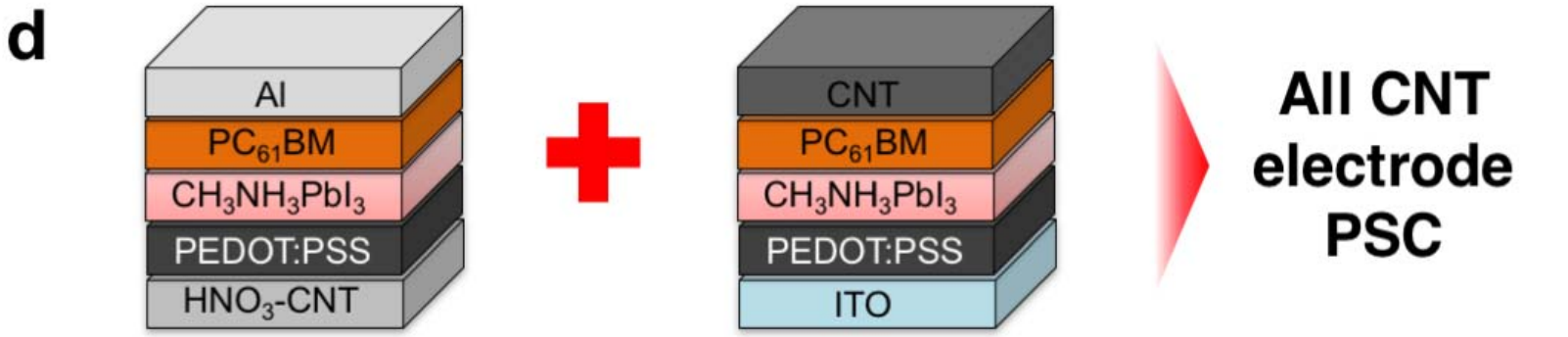
Takahiro Sakaguchi,Il Jeon,Takaaki Chiba,Ahmed Shawky, Esko I. Kauppinen,Rong Xiang,Shohei Chiashi, Nam-Gyu Park*,Yutaka Matsuo*,Shigeo Maruyama*

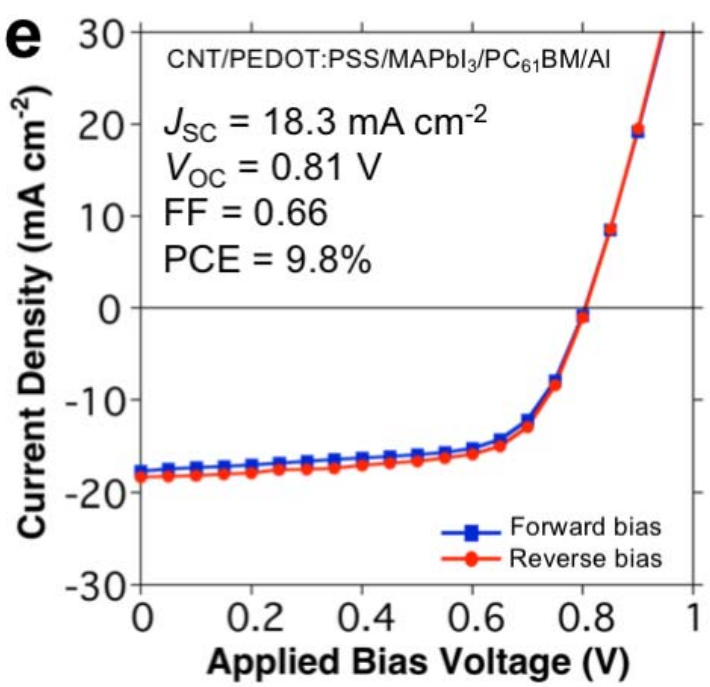
CNT Electrode in Perovskite Solar Cells

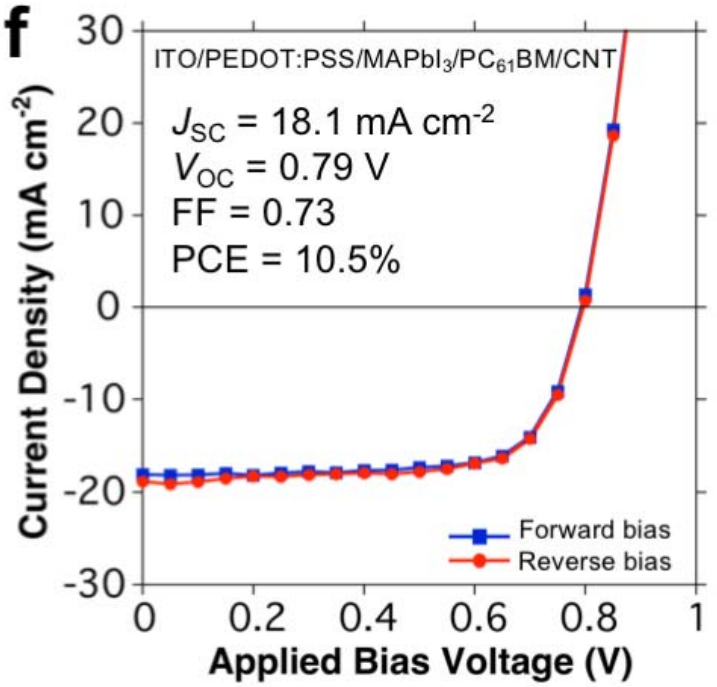


Namyoung Ahn, Il Jeon, Jungjin Yoon, Esko I. Kauppinen, Yutaka Matsuo*, Shigeo Maruyama*, Mansoo Choi*, J. Mater. Chem. A, 6(2018)1382.

$PC_{61}BM$-Soaked CNTs as Cathode



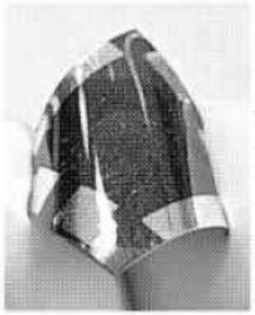




Il Jeon, Seungju Seo, Yuta Sato, Clement Delacou, Anton Anisimov, Kazu Suenaga, Esko I. Kauppinen, Shigeo Maruyama*, Yutaka Matsuo*, J. Phys. Chem. C, 121 (2017) 25743.

athode and Anode Electrodes

2018/2/26 日本経済新聞



太陽電池 製造コスト半分

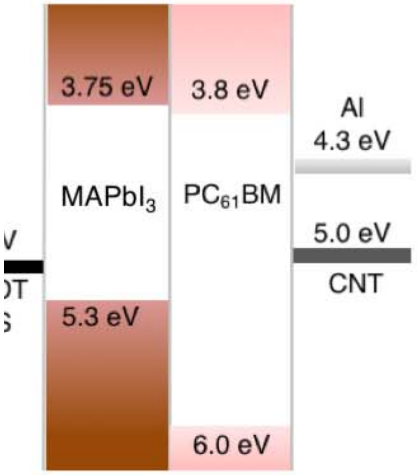
素材 金属からナノチューブに

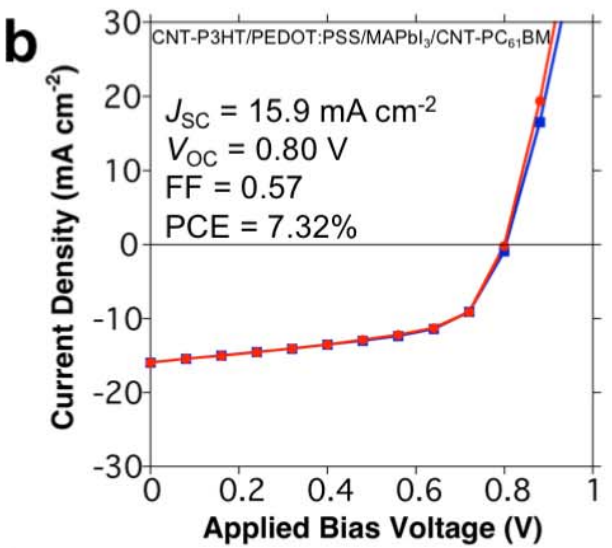
東大、車など曲面向け

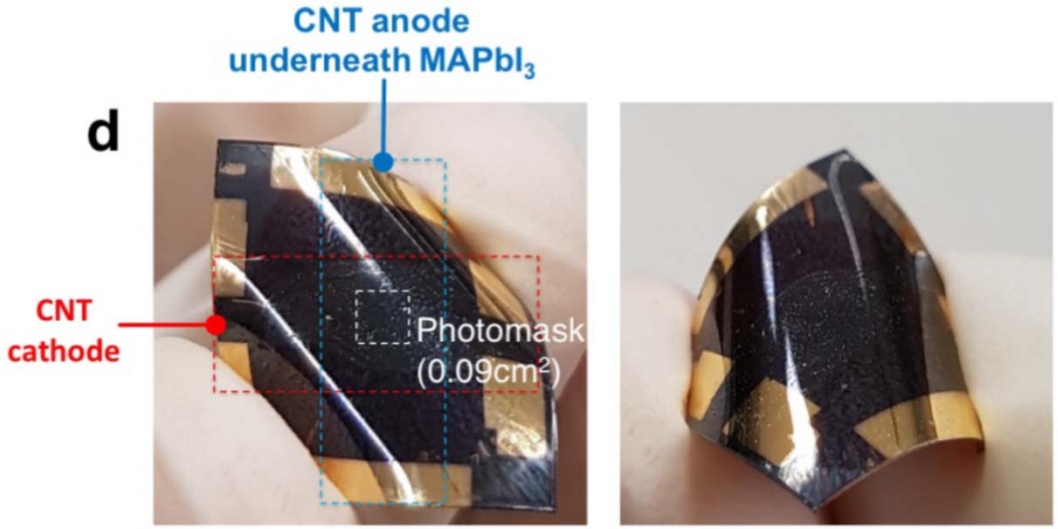
東京大学の丸山茂夫教授と松尾豊特任教授らは、製造コストを半分にできる薄型太陽電池を開発した。電極材料を従来の金属から筒状炭素分子「カーボンナノチューブ」に変え、電気代などコストがかさむ真空での作業工程をなくした。材料メーカーなどと組み、数年後の実用化を目指す。

開発したのは「ペロブスカイト型」と呼ばれる有機太陽電池の一種＝写真は東大提供。薄く柔らかいので折り曲げて、自動車の車体や建物の曲面などに設置できる。1・5㌢㍍角の試作品は電極にインジウムなどの代わりにカーボンナノチューブを使った。球状炭素分子「フラーレン」の一種と組み合わせて電気を取り出しやすくした。発電効率は7%と主流のシリコン製より低いが、今後の研究で改善できるとみている。

金属製電極を作る場合、高価な製造設備を使う真空蒸着といった工程が必要だった。カーボンナノチューブは合成樹脂などの基板に塗るだけで電極になる。使用量も少なく全体では安くなるという。

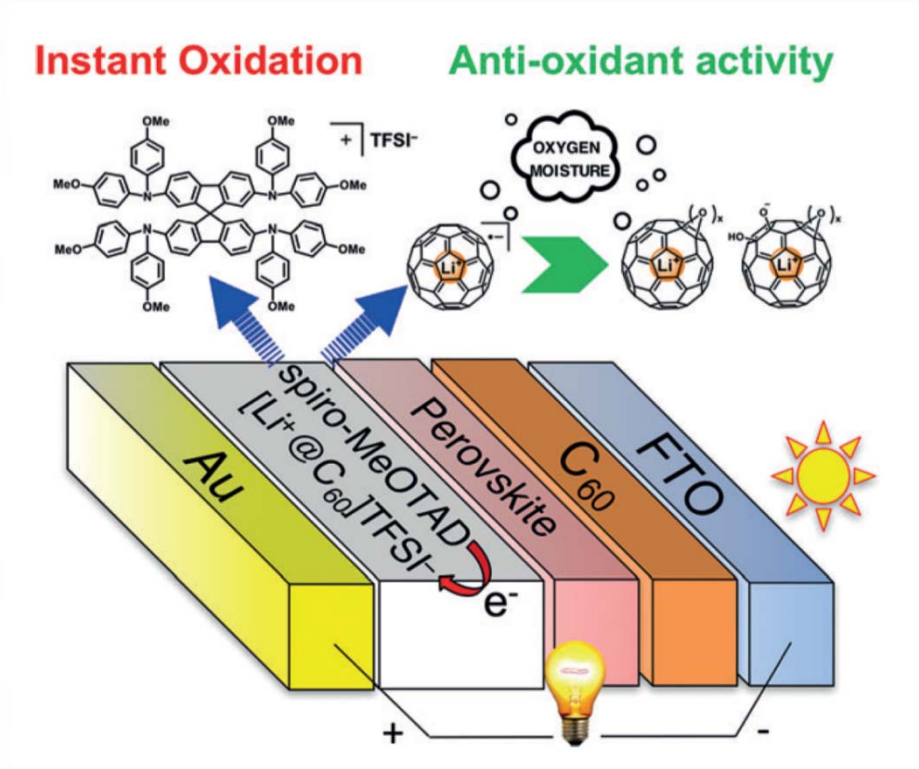


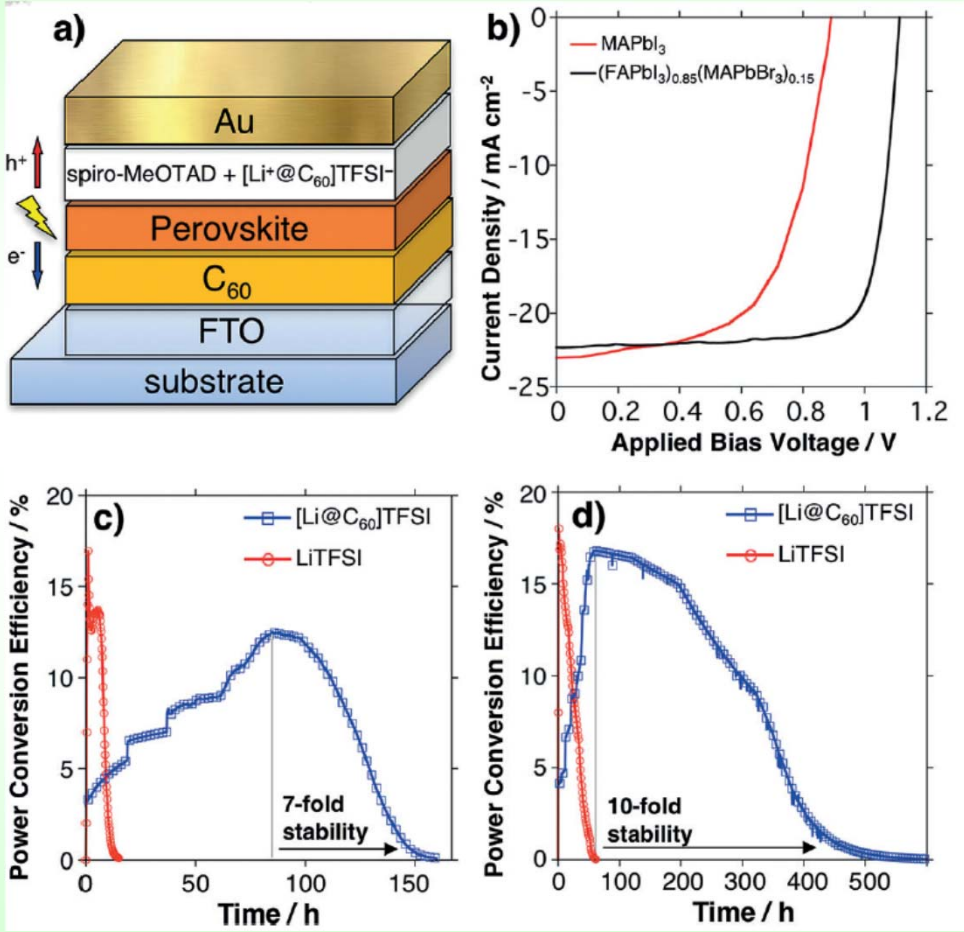




to, Clement Delacou, Anton Anisimov, Kazu Suenaga,
ma*, Yutaka Matsuo*, J. Phys. Chem. C, 121 (2017) 25743.

Metal endohedral fullerene, $Li^+@C_{60}$





I. Jeon, H. Ueno, S. Seo, K. Aitola, R. Nishikubo, A. Saeki, H. Okada, G. Boschloo, S. Maruyama, Y. Matsuo, Angew. Chem. Int. Ed. 2018, in press. [DOI: 10.1002/anie.201800816].

東京大学
THE UNIVERSITY OF TOKYO

Thank you

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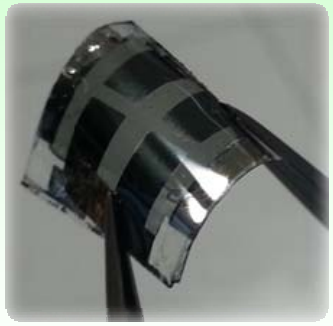
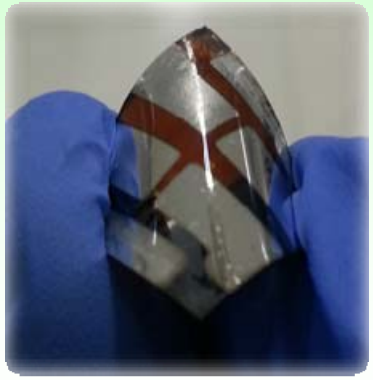
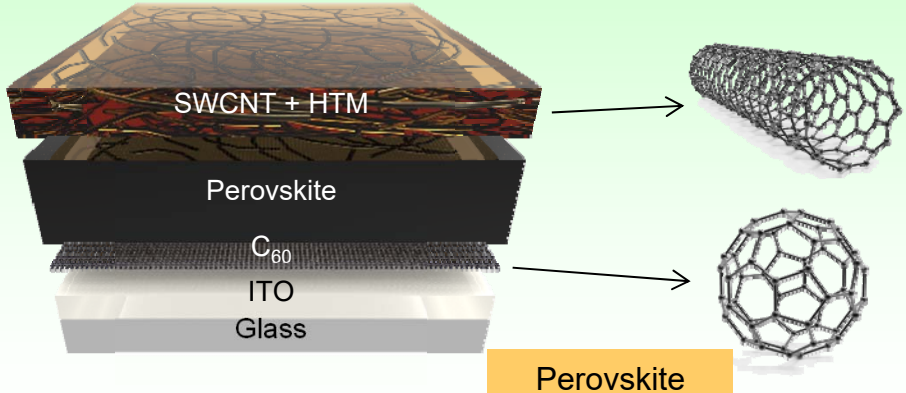


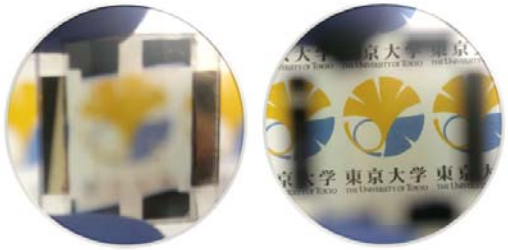
Organic Thin Film (Normal)



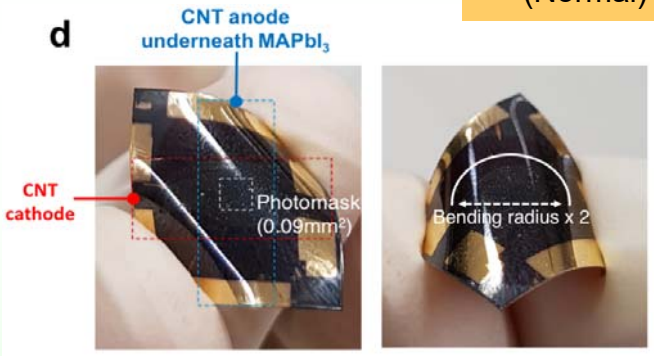
Perovskite (Inverted)



Perovskite (Normal)



Organic Thin Film (Inverted)



Perovskite CNT for Anode and Cathode

SATL
Science of Atomic Layers

*IRENA Project by JST-EC DG RTD, Strategic International Collaborative Research Program, SICORP
*JSPS KAKENHI Grant Numbers JP25107002, JP15H05760
*Project of the New Energy and Industrial Technology Development Organization (NEDO) of Japan.

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