INTERACTIVE PEROVSKITE SOLAR CELLS: New adventures in self-powered IoT devices

Matt Carnie – Swansea University
ICPHPV 2019 New Delhi

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Ten years of perovskite PV

Electroluminescence from an Organic−Inorganic Perovskite Incorporating a Quaterthiophene Dye within Lead Halide Perovskite Layers

Konstantinos Chondroudis and David B. Mitzi*

IBM T. J. Watson Research Center, P.O. Box 218, Yorktown Heights, New York 10598

Received September 2, 1999

Organic−inorganic hybrids are a technologically im-

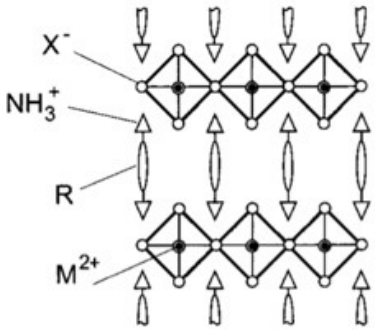

Figure 1. Schematic of the structure of the $(H_3N-R-NH_3)$-MX_4 perovskite family.

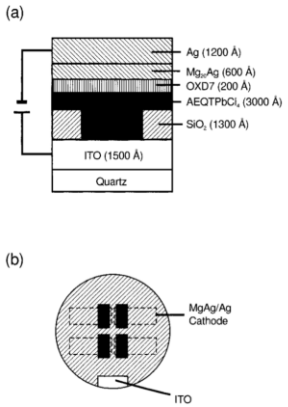

Figure 2. (a) Cross-section of the OILED device structure (not to scale) and (b) a circular quartz substrate containing four devices (bottom view).

1999

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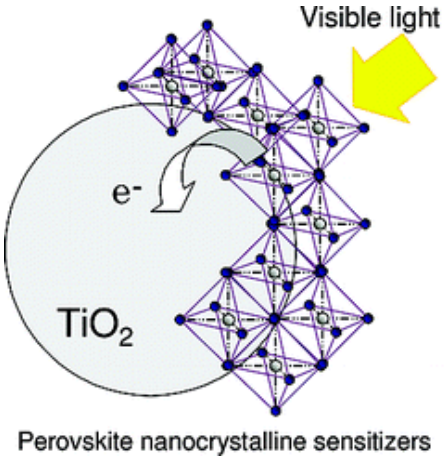
J|A|C|S COMMUNICATIONS

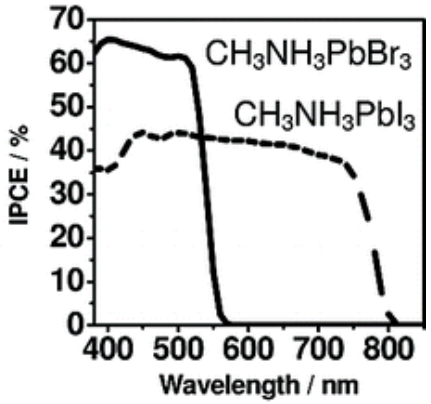
Published on Web 04/14/2009

Organometal Halide Perovskites as Visible-Light Sensitizers for Photovoltaic Cells

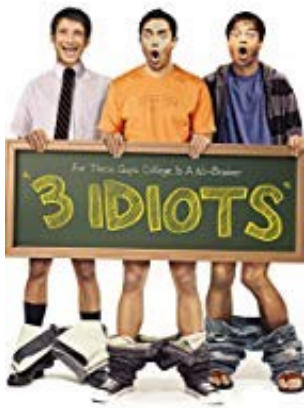
Akihiro Kojima,[†] Kenjiro Teshima,[‡] Yasuo Shirai,[§] and Tsutomu Miyasaka*[,†,‡,||]



Perovskite nanocrystalline sensitizers



2009



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SCIENTIFIC REPORTS

OPEN

SUBJECT AREAS:
NANOPHOTONICS
OPTICAL MATERIALS AND DEVICES
INORGANIC CHEMISTRY
APPLIED PHYSICS

Received
5 July 2012

Lead Iodide Perovskite Sensitized All-Solid-State Submicron Thin Film Mesoscopic Solar Cell with Efficiency Exceeding 9%

Hui-Seon Kim[1], Chang-Ryul Lee[1], Jeong-Hyeok Im[1], Ki-Beom Lee[1], Thomas Moehl[2], Arianna Marchioro[2], Soo-Jin Moon[2], Robin Humphry-Baker[2], Jun-Ho Yum[2], Jacques E. Moser[2], Michael Grätzel[2] & Nam-Gyu Park[1]

Efficient Hybrid Solar Cells Based on Meso-Superstructured Organometal Halide Perovskites

Science AAAS

Michael M. Lee,[1] Joël Teuscher,[1] Tsutomu Miyasaka,[2] Takurou N. Murakami,[2,3] Henry J. Snaith[1]*

The energy costs associated with separating tightly bound excitons (photoinduced electron-hole pairs) and extracting free charges from highly disordered low-mobility networks represent fundamental losses for many low-cost photovoltaic technologies. We report a low-cost, solution-processable solar cell, based on a highly crystalline perovskite absorber with intense visible to near-infrared absorptivity, that has a power conversion efficiency of 10.9% in a single-junction device under simulated full sunlight. This "meso-superstructured solar cell" exhibits exceptionally few fundamental energy losses; it can generate open-circuit photovoltages of more than 1.1 volts, despite the relatively narrow absorber band gap of 1.55 electron volts. The functionality arises from the use of mesoporous alumina as an inert scaffold that structures the absorber and forces electrons to reside in and be transported through the perovskite.

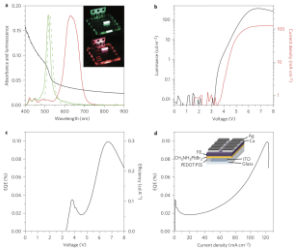
2012

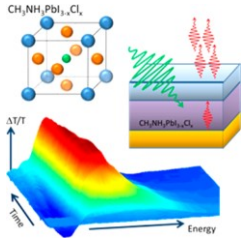
Ten years of perovskite PV

nature nanotechnology
LETTERS
PUBLISHED ONLINE: 3 AUGUST 2014 | DOI: 10.1038/NNANO.2014.149

Bright light-emitting diodes based on organometal halide perovskite

Zhi-Kuang Tan[1], Reza Saberi Moghaddam[1], May Ling Lai[1], Pablo Docampo[2], Ruben Higler[1], Felix Deschler[1], Michael Price[1], Aditya Sadhanala[1], Luis M. Pazos[1], Dan Credgington[1], Fabian Hanusch[2], Thomas Bein[2], Henry J. Snaith[3] and Richard H. Friend[1]*





THE JOURNAL OF PHYSICAL CHEMISTRY Letters
Letter
pubs.acs.org/JPCL

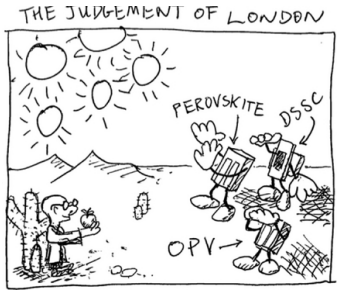
High Photoluminescence Efficiency and Optically Pumped Lasing in Solution-Processed Mixed Halide Perovskite Semiconductors

Felix Deschler,[†,§] Michael Price,[†,§] Sandeep Pathak,[†,‡] Lina E. Klintberg,[†] David-Dominik Jarausch,[†] Ruben Higler,[†] Sven Hüttner,[†] Tomas Leijtens,[‡] Samuel D. Stranks,[‡] Henry J. Snaith,[*,‡] Mete Atatüre,[†] Richard T. Phillips,[†] and Richard H. Friend[*,†]

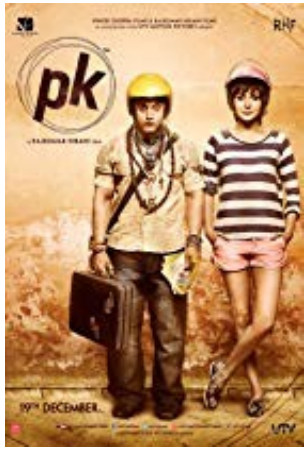
COMMUNICATION
ADVANCED MATERIALS
www.advmat.de
Materials Views
www.MaterialsViews.com

Performance and Stability of Lead Perovskite/TiO_2, Polymer/PCBM, and Dye Sensitized Solar Cells at Light Intensities up to 70 Suns

*Chunhung Law, Lukas Miseikis, Stiochko Dimitrov, Pabitra Shakya-Tuladhar, Xiaoe Li, Piers R. F. Barnes, James Durrant, and Brian C. O'Regan**



2014



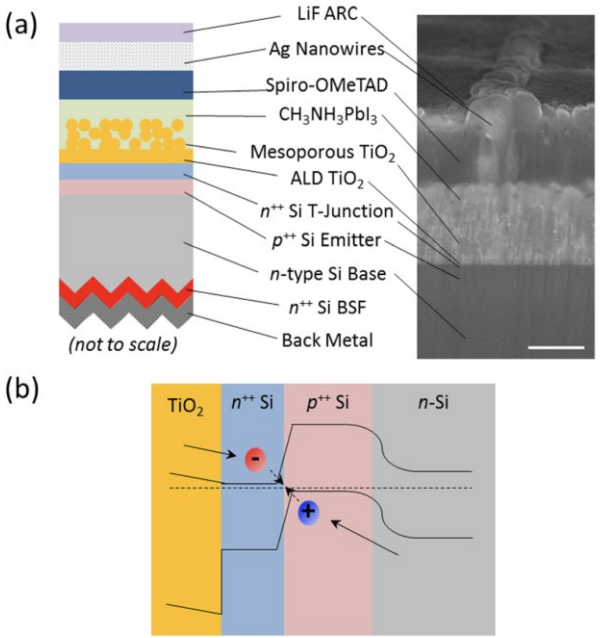
Ten years of perovskite PV

APPLIED PHYSICS LETTERS **106**, 121105 (2015)

A 2-terminal perovskite/silicon multijunction solar cell enabled by a silicon tunnel junction

Jonathan P. Mailoa,[1,a),b)] Colin D. Bailie,[2,a)] Eric C. Johlin,[1] Eric T. Hoke,[2] Austin J. Akey,[1] William H. Nguyen,[2] Michael D. McGehee,[2,b)] and Tonio Buonassisi[1,b)]
[1]*Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*
[2]*Stanford University, Stanford, California 94305, USA*

(Received 4 February 2015; accepted 23 February 2015; published online 24 March 2015)



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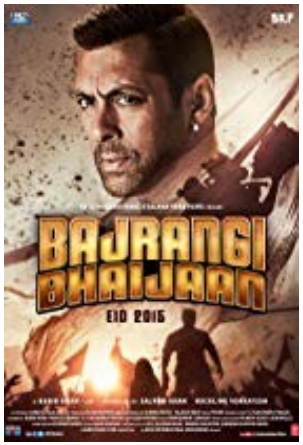

Ten years of perovskite PV

[redacted]

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Perovskite Photovoltaic Cells

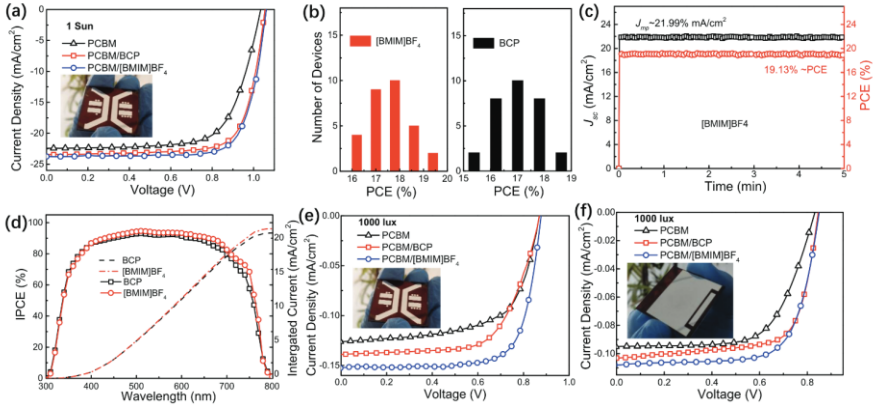
Solar RRL

www.solar-rrl.com

Check for updates

Outstanding Indoor Performance of Perovskite Photovoltaic Cells – Effect of Device Architectures and Interlayers

*Harrison Ka Hin Lee, Jérémy Barbé, Simone M. P. Meroni, Tian Du, Chieh-Ting Lin, Adam Pockett, Joel Troughton, Sagar M. Jain, Francesca De Rossi, Jennifer Baker, Matthew J. Carnie, Martyn A. McLachlan, Trystan M. Watson, James R. Durrant, and Wing C. Tsoi**



FULL PAPER

Perovskite Solar Cells

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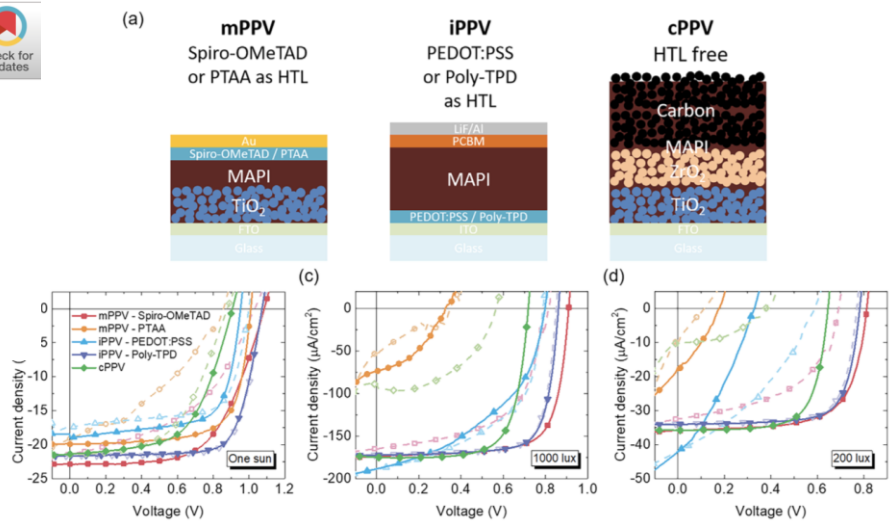
Interface Modification by Ionic Liquid: A Promising Candidate for Indoor Light Harvesting and Stability Improvement of Planar Perovskite Solar Cells

Meng Li, Chao Zhao, Zhao-Kui Wang, Cong-Cong Zhang, Harrison K. H. Lee, Adam Pockett, Jérémy Barbé, Wing Chung Tsoi, Ying-Guo Yang, Matthew J. Carnie, Xing-Yu Gao, Wen-Xing Yang, James R. Durrant, Liang-Sheng Liao,* and Sagar M. Jain**



Ten years of perovskite PV

- Efficient single- and multi- junction solar cells ✔
- Efficient LEDs ✔
- Lasing ✔
- Possible concentrator application ✔
- Superior low-light performance ✔

What else can we do?

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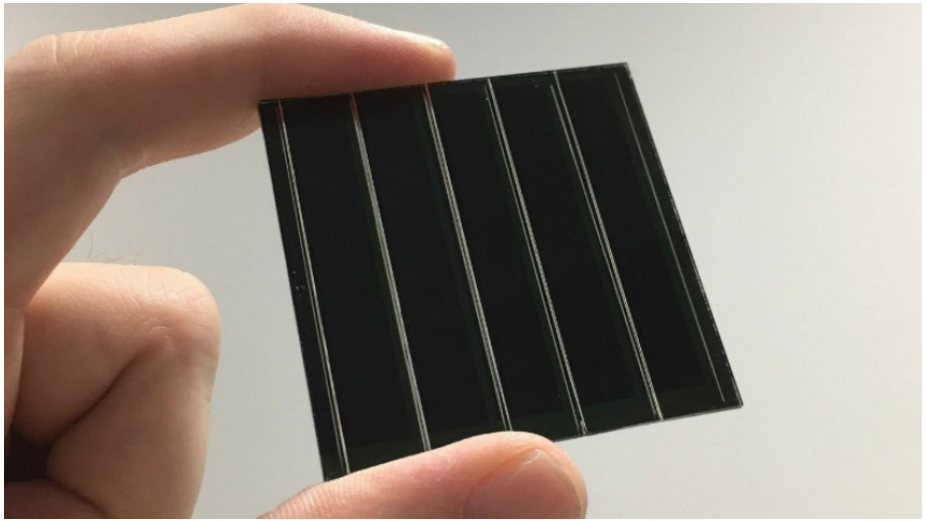
Materials Science and Human Computer Interaction



Computational Foundry

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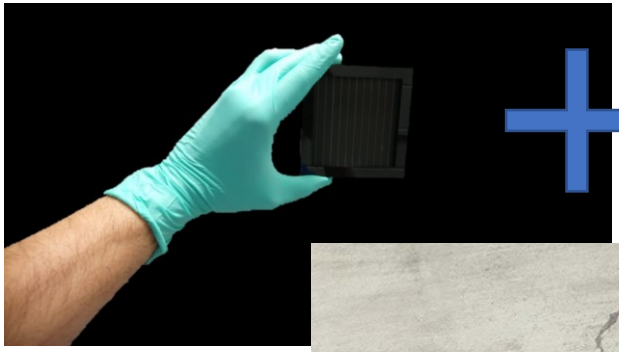
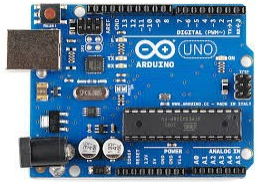
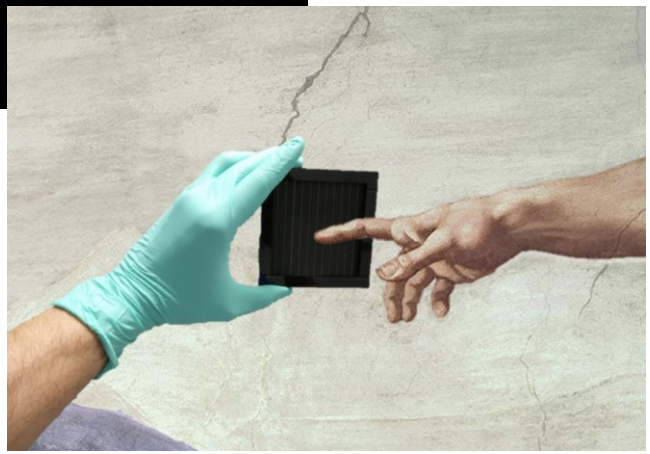
Self powered IoT







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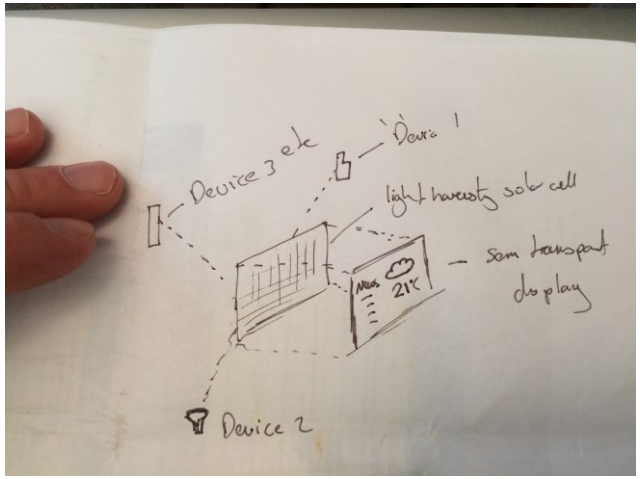
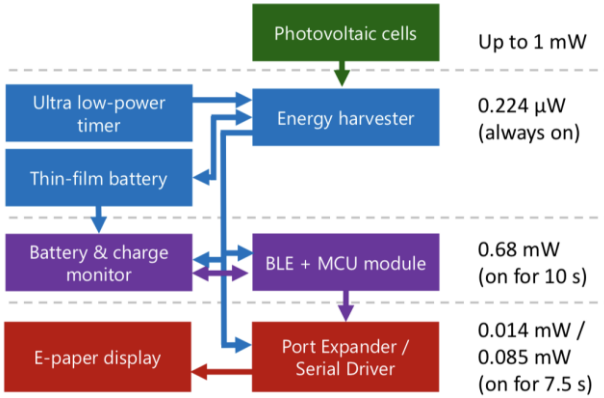
Interactive photovoltaic tiles





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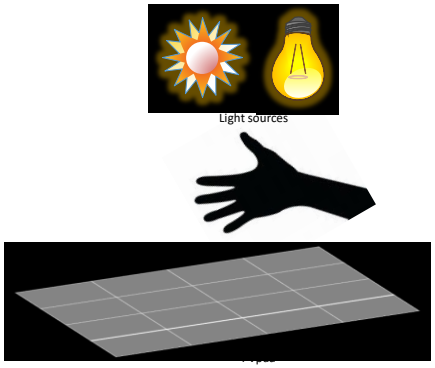

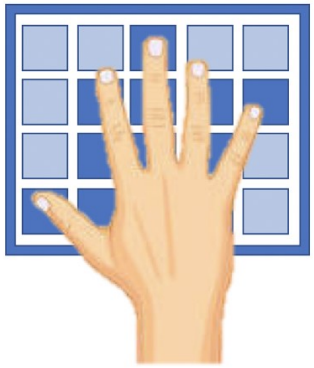

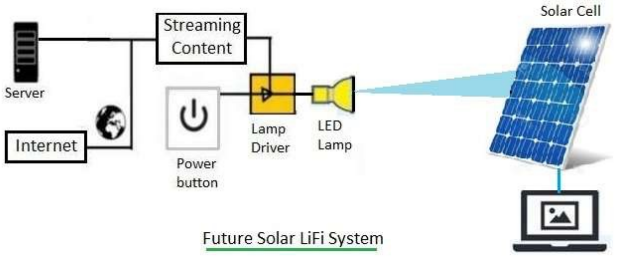

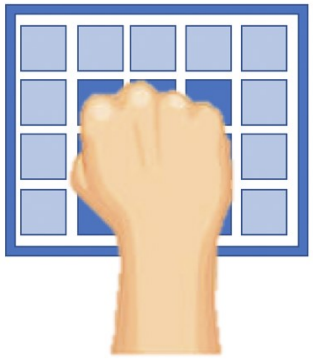

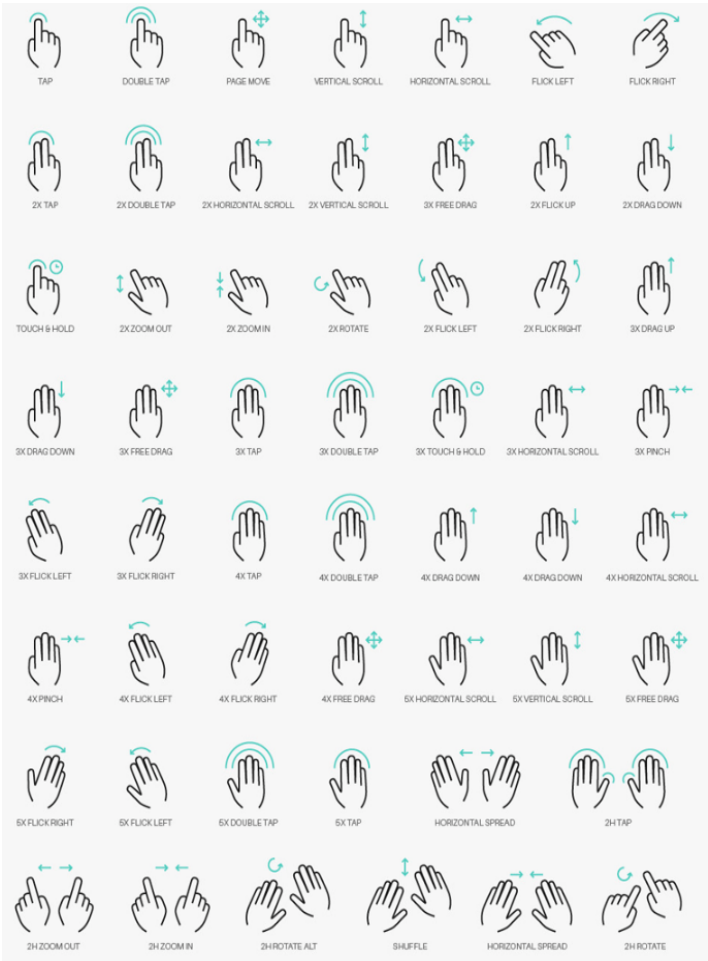

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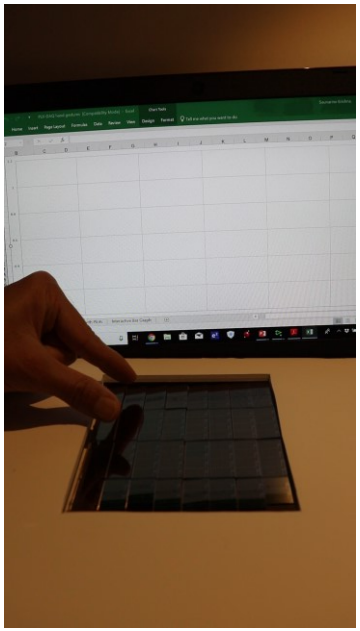
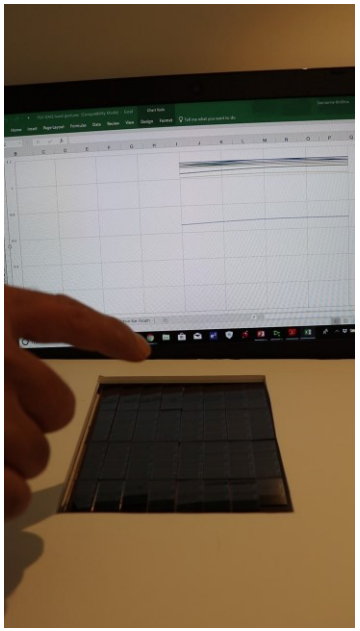
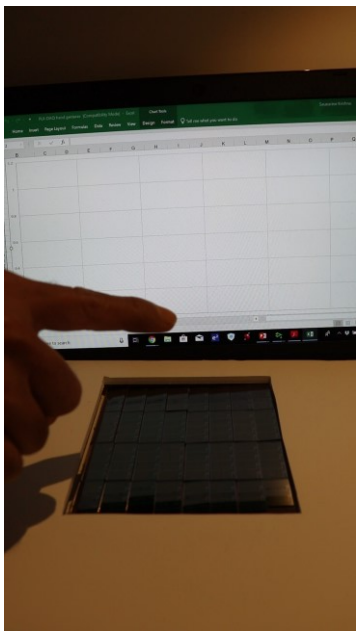
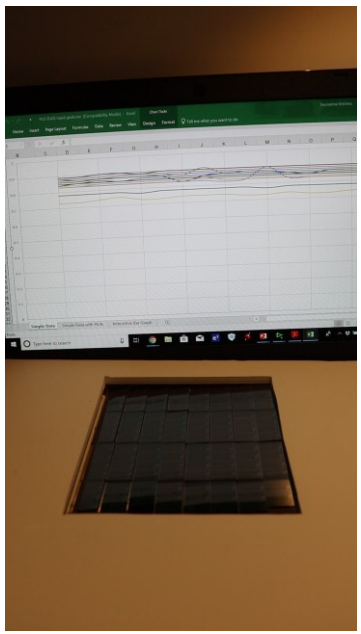
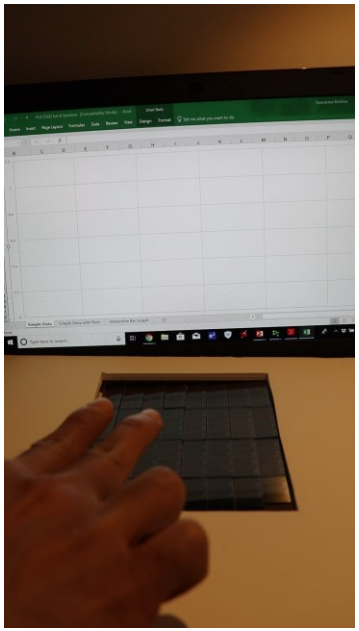
Gesture detection

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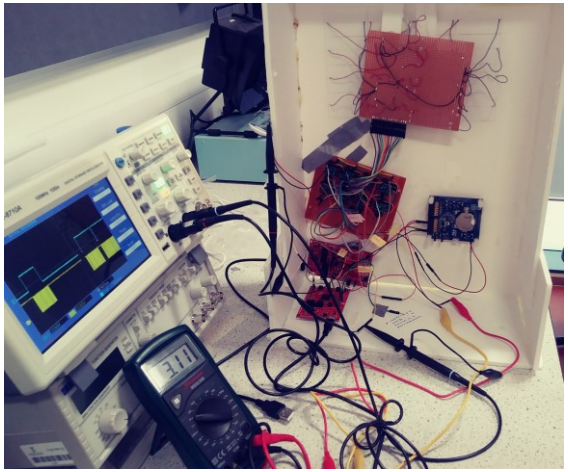

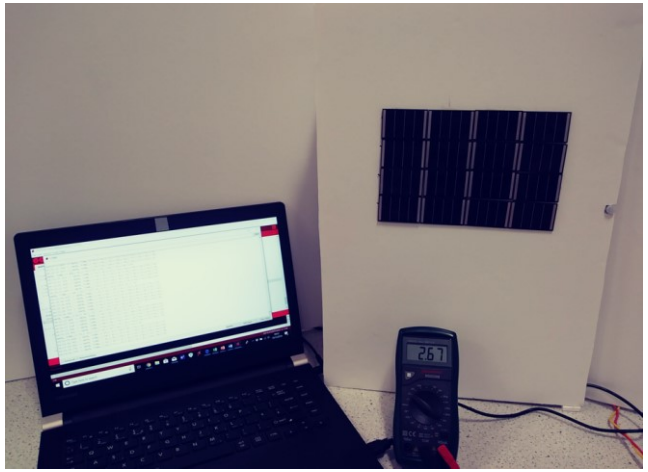

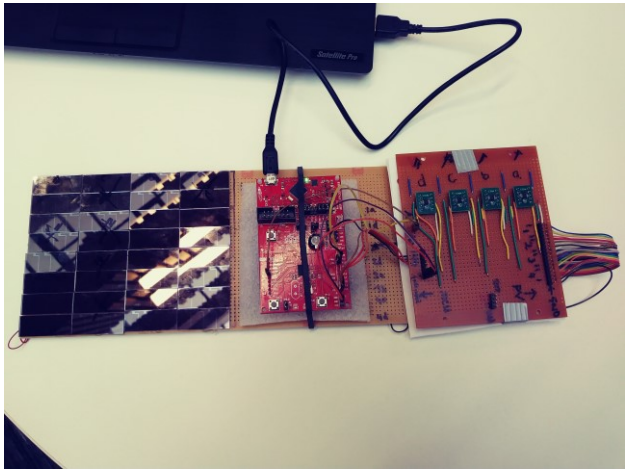

Power Consumption

Energy harvesting mode:	2.4 µA @3V	**7 µW**
Gesture mode:	500 µA @ 3V	**1.5 mW**

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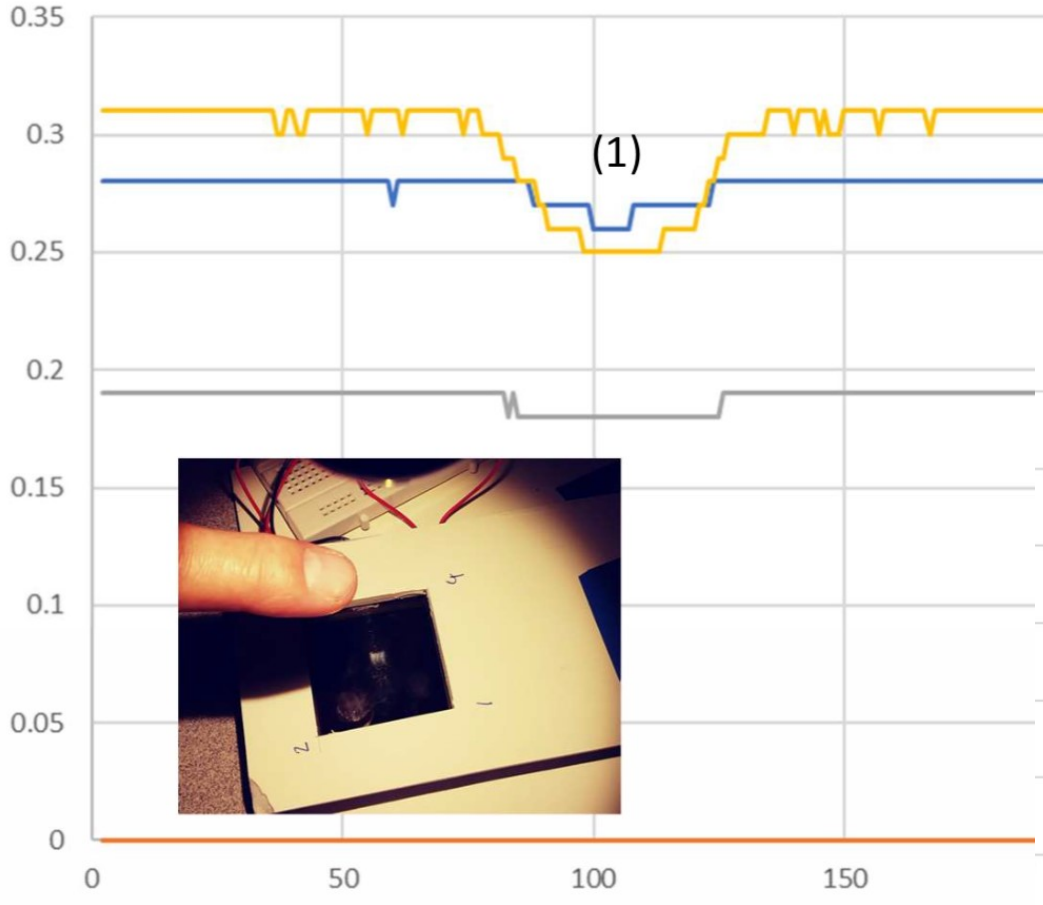
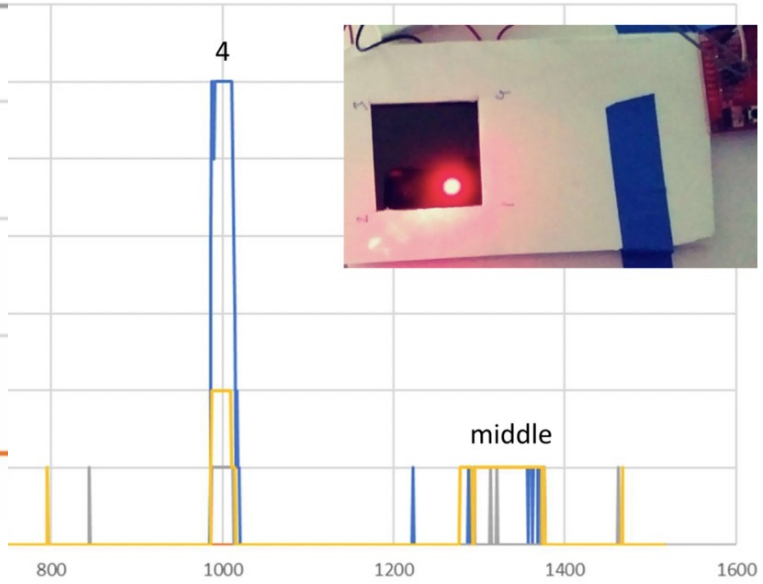
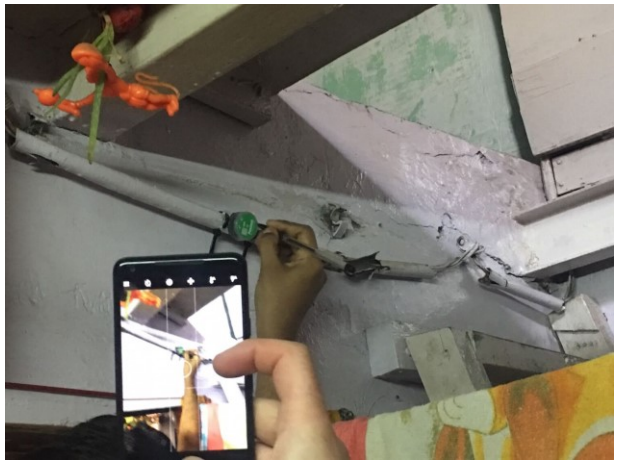
Perovskite touchpad



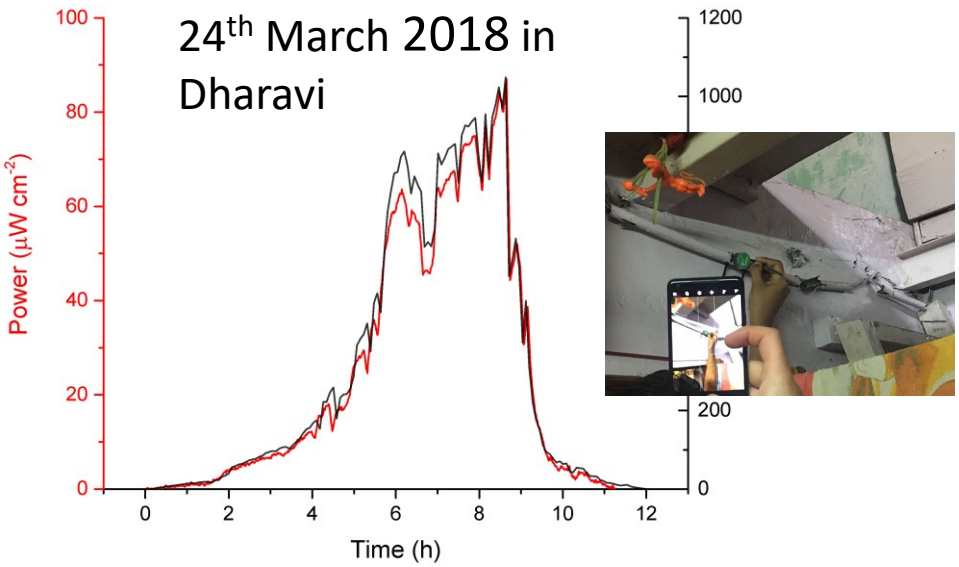


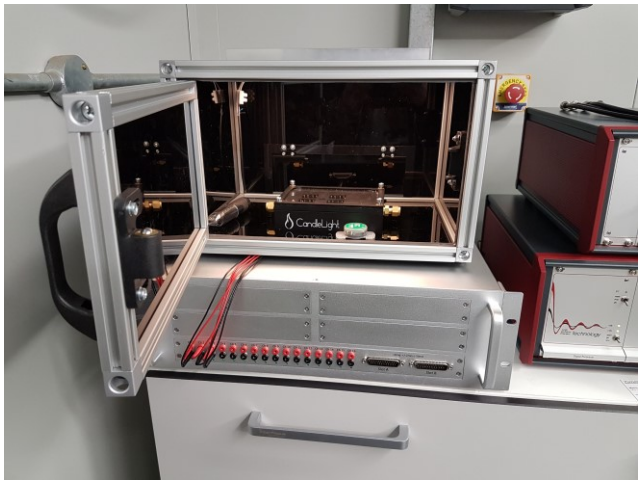
Variable light intensity MPPT

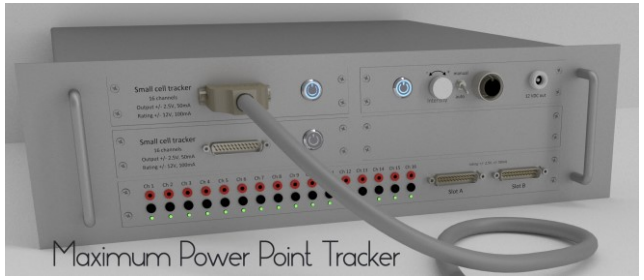
- We calculate *power* regularly using the IV curve
- If you want to power a device *energy yield* is more important
- Becomes complicated if light intensity is variable

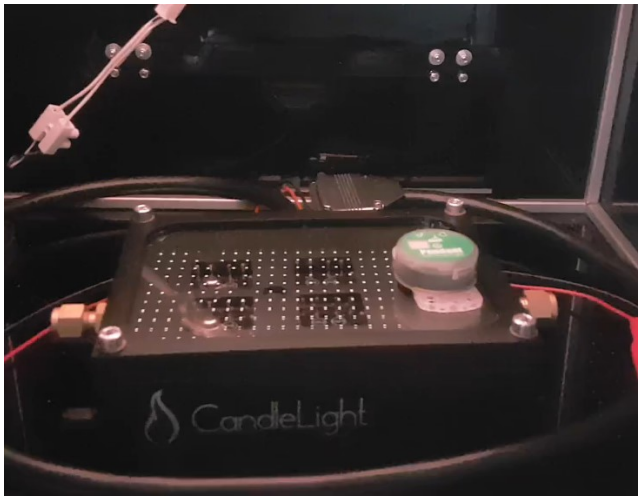


Variable light intensity MPPT

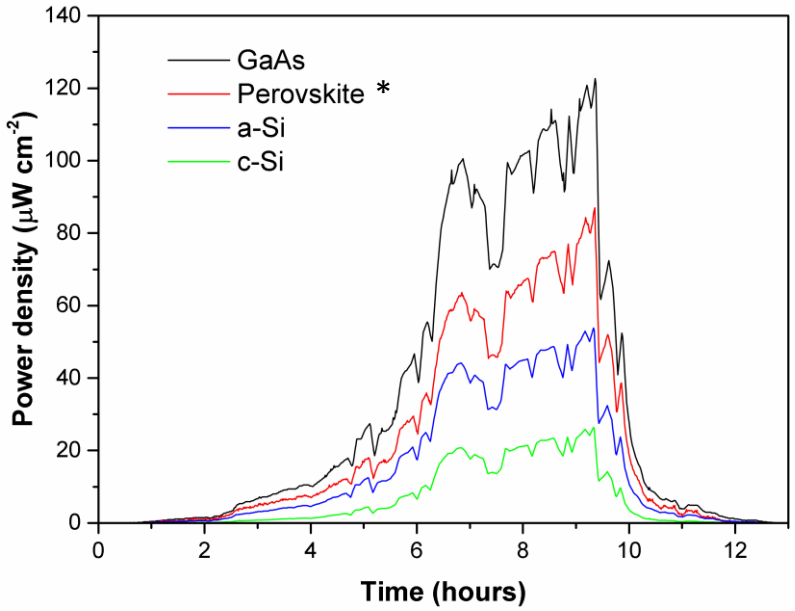


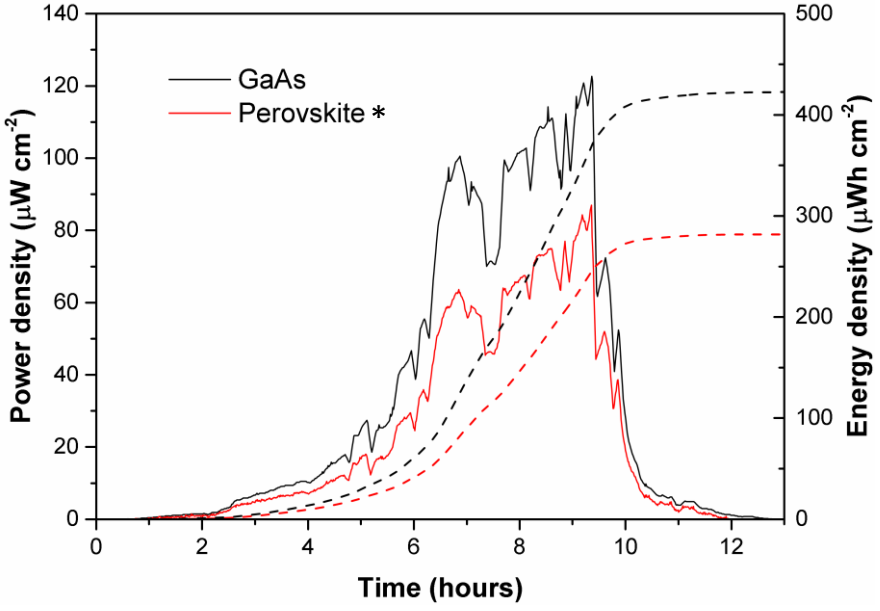






Energy yield





* Unencapsulated perovskite cell, old/degraded, not optimised for low light harvesting

Conclusions

- Don’t ask Shania Twain about perovskite materials
- (Oooh) I think they’re something special
- (Oooh) I think they’re something else
- They impress me much

- They have superior indoor performance
- Energy yield more important than IV-MPP when you have to power some devices in variable lighting
- Energy yield enough to power low consumption IoT devices

Acknowledgements

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Google

Microsoft Research Cambridge

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