specific

Perovskite powered IoT

Suzanne Thomas

Our group (PV)

- Group leader: Matt Carnie
- Postdocs:
  - Adam Pockett (CELIV, TPV, electrical characterisation)
  - Suzanne Thomas (PSC's for IoT and indoor use, AFM/SKPM)
- PhD students:
  - Michael Spence (Silicon/perovskite tandem cells)
  - Gethin Thomas (PV IoT integration, gesture tech with PV)

Swansea University
Prifysgol Abertawe

specific
SPARC II
Building research capacity in solar photovoltaic technology

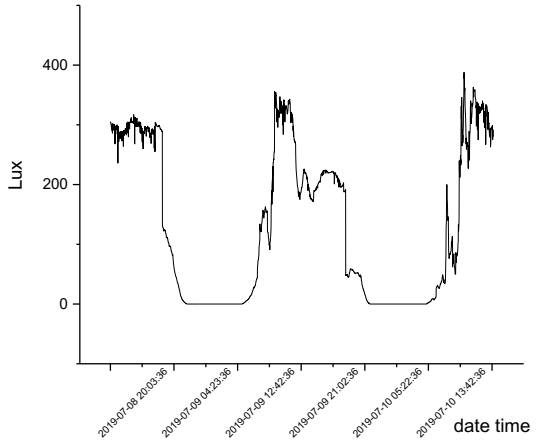
Why?

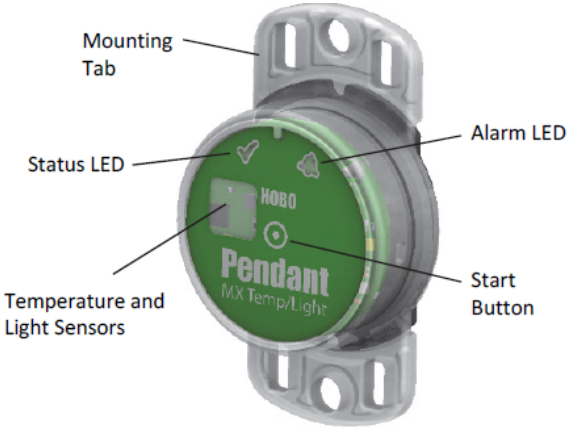
- IoT connectivity in homes is increasing
- Requires an off-grid solution to offset increased power consumption in homes and offices
- Perovskites are cheap, easy to produce, and solution processable.

Previous studies

- Varied intensity fluorescent lamp, tracking MPP: for PSC
- CFL @ 200 Lux, LED @200 Lux, 1 sun for dye cells
- 200 Lux fluorescent lamp. Dye cells and PSCs
- Transparent OPV under solar sim and LED
- 1 sun and 200 Lux fluorescent lamps: PSC and carbon cell

- C. Chen et al.:**10.1002/adfm.201503448**
- F. De Rossi et al.: **http://dx.doi.org/10.1016/j.apenergy.2015.07.031**
- S. Juang et al.: **10.3389/fchem.2019.00209**
- S. Kim et al.: **10.2174/1570180816666190112141857**
- H. K. H. Lee et al.: **10.1002/solr.201800207**





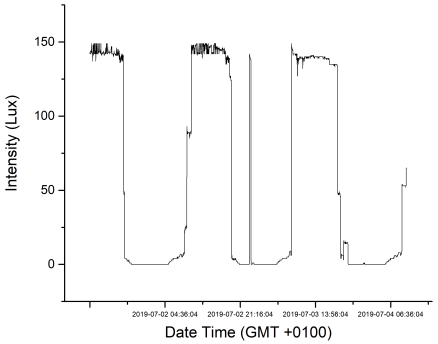
Realistic data acquisition

- Standard 200/1000 Lux IV curves
- Collect real-time data from office scenario using data logger

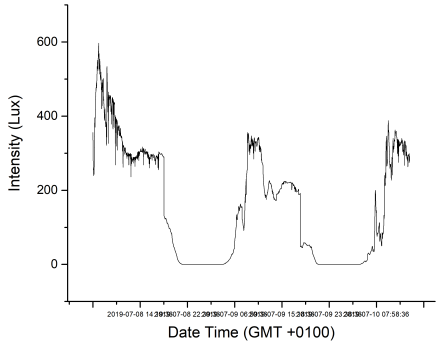
All scenarios

- Recommended 200-500 lux.
- 200 or 1000 lux are unreasonable expectations for testing especially ‘low light’.

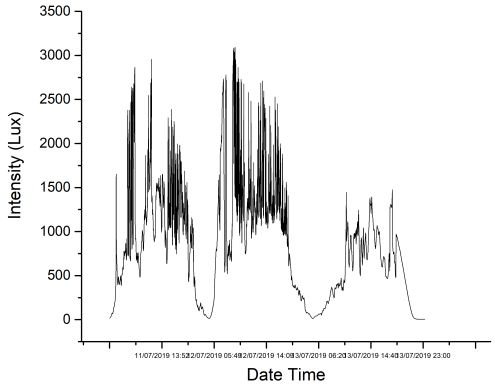
Office with no natural light



Office with incident natural light

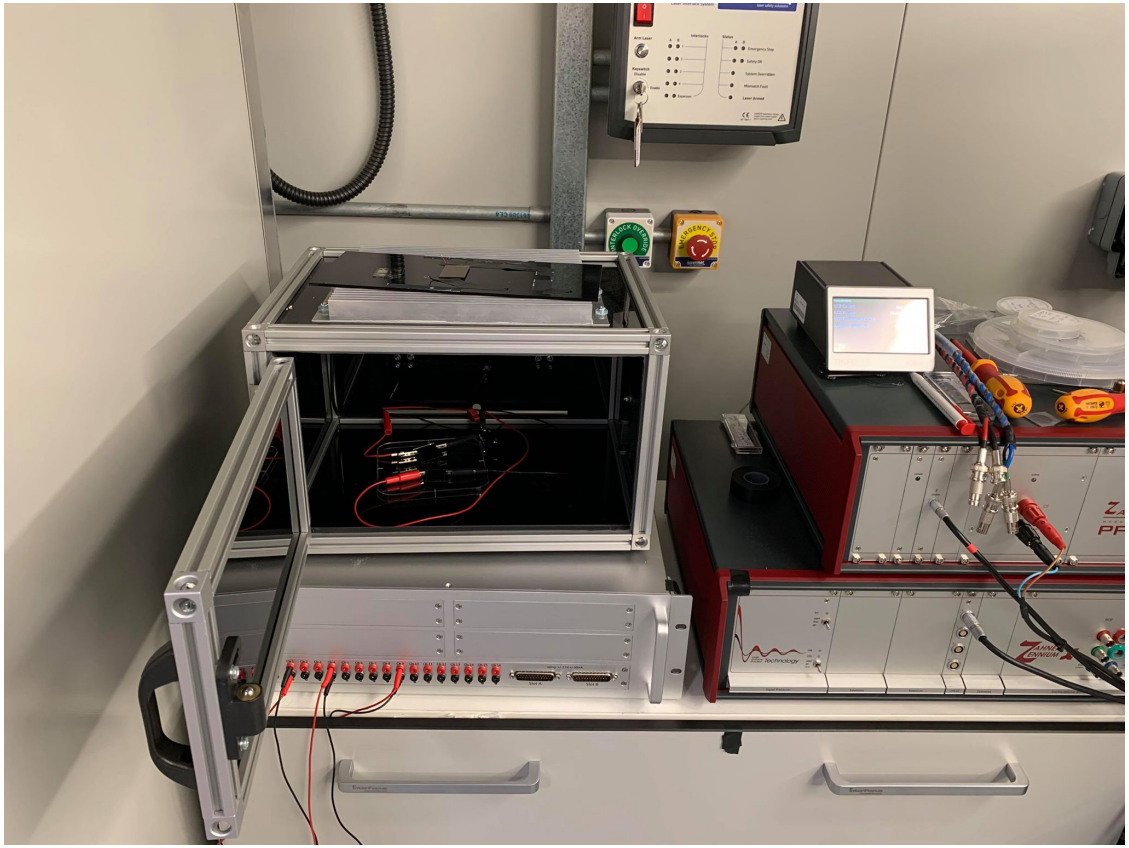


Covered external walkway



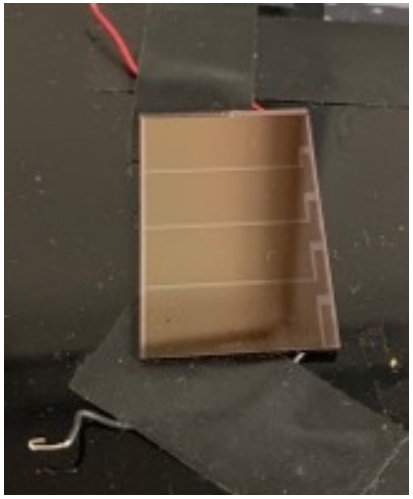
Real data testing

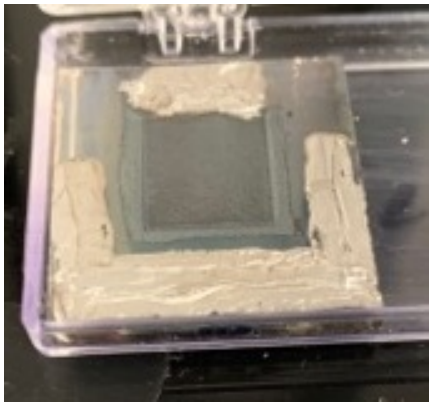
- Using a candlelight ageing LED setup
- Convert recorded lux values
- Use MPPT

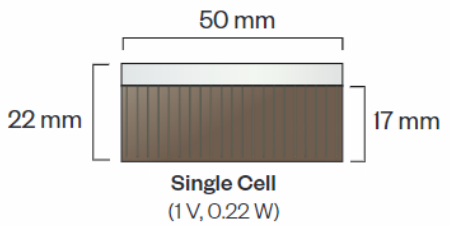


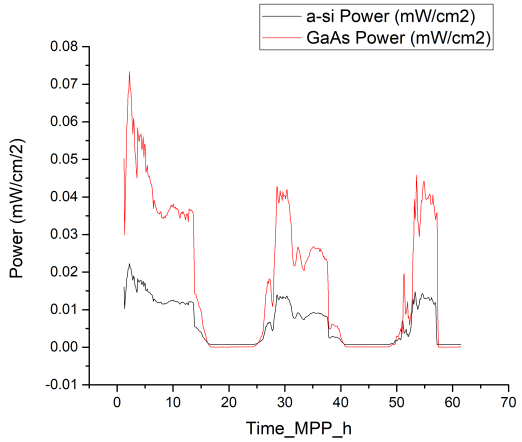
What cells are we testing

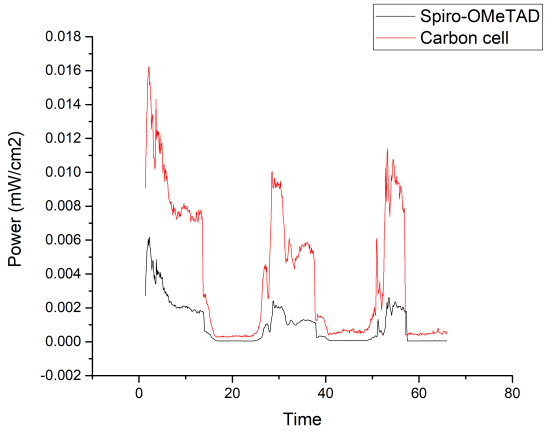
- Premade commercially available
  - a-Si – 13.75 cm^2
  - GaAs – 8.5 cm^2
- Inhouse solution processed
  - ITO/NiOx/MAPI/PCBM/BCP/Ag – 2 x 1 cm^2
  - ITO/SnO(np)/MAPI/spiro-OMeTAD/Au – 2 x 1 cm^2
- Inhouse carbon cell TiO_2/Perovskite/Carbon – 1 cm^2

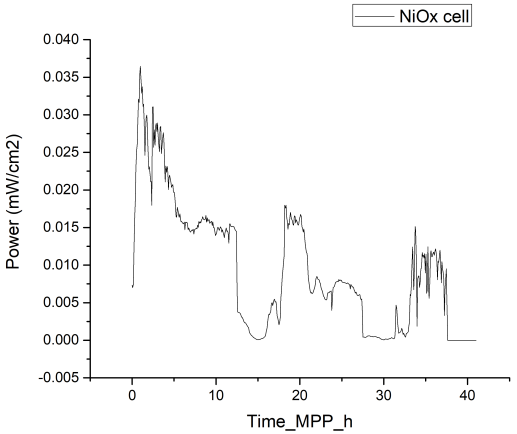






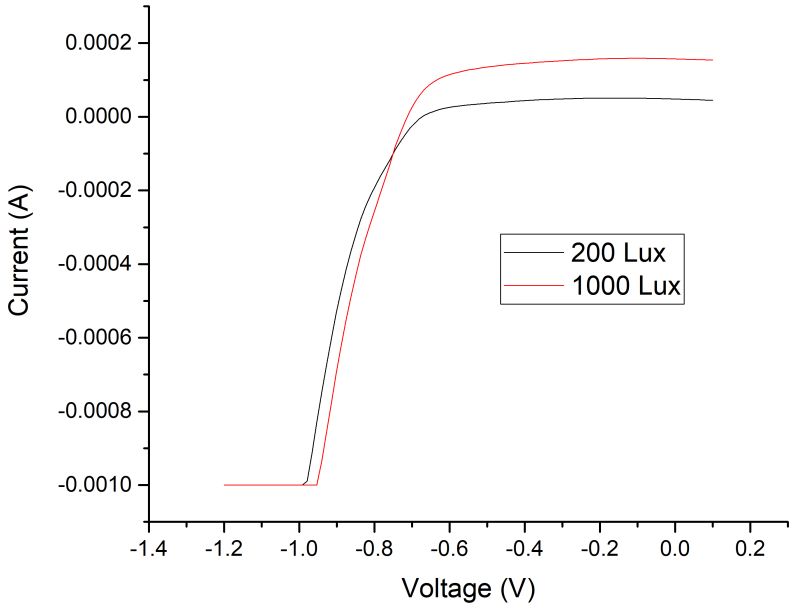

a-si Power (mW/cm2)
GaAs Power (mW/cm2)
Power (mW/cm/2)
Time_MPP_h

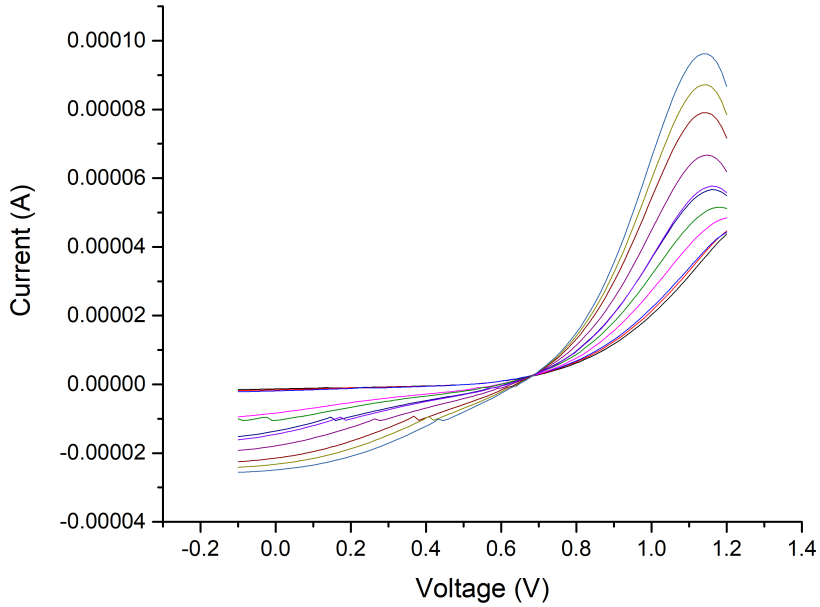

Spiro-OMeTAD
Carbon cell
Power (mW/cm2)
Time


NiOx cell
Power (mW/cm2)
Time_MPP_h

Results

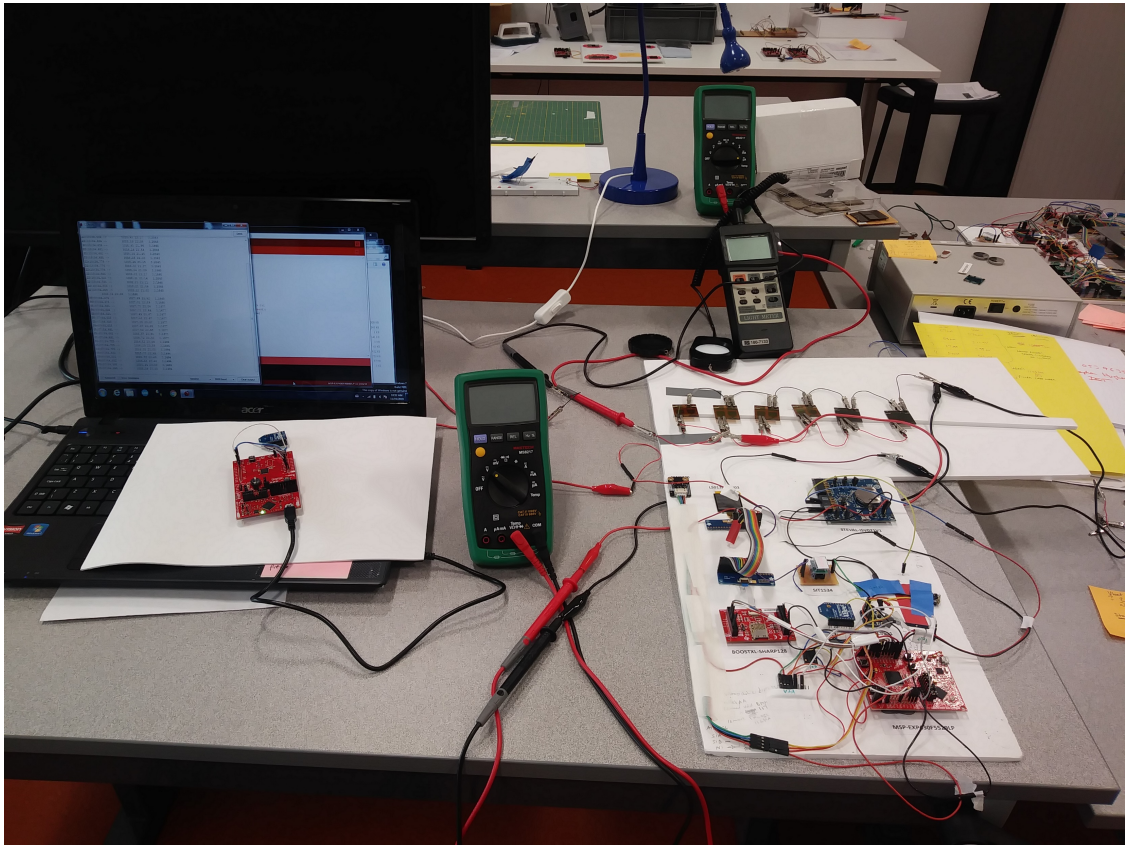
Low light IV curves





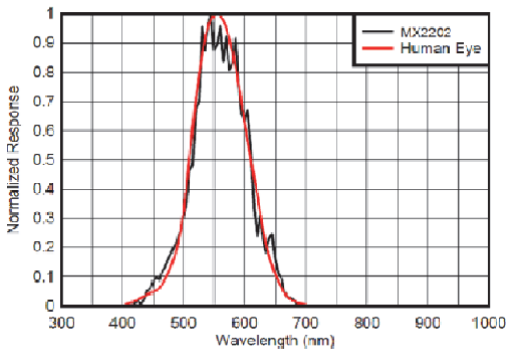
Prototype IoT

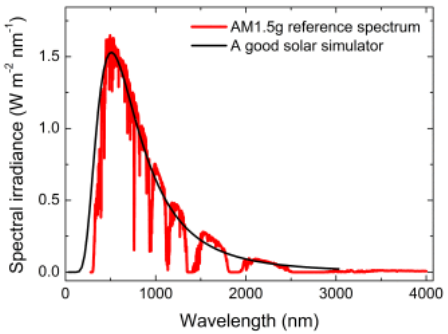
- Pressure and temperature sensor
- Update time is adjustable
- Peak current – 276 µA when updating, 9.5 µA when idle.



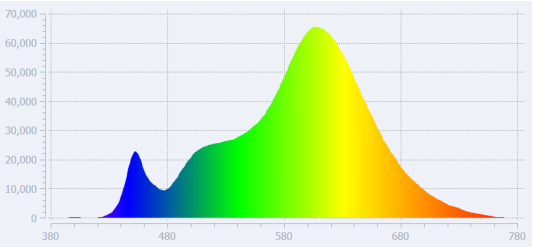
Limitation – Spectral mismatch

- The spectrum recorded by the data logger is like the spectral response of the human eye
- The spectral response of the cell will vary in the solar simulator light, LED array, and actual conditions.

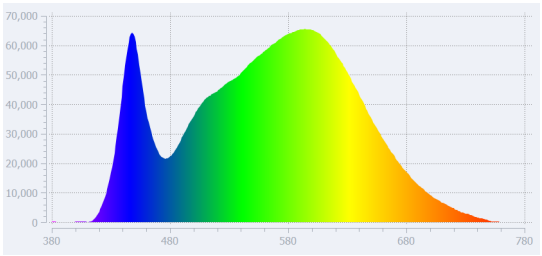




Office spectrum



LED array spectrum



Spectral mismatch factor

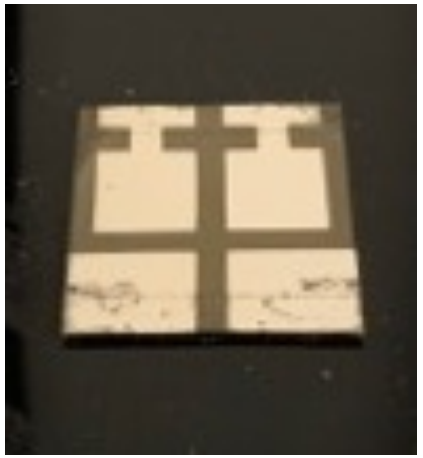
- Spectrum of the sun compared to spectrum of the simulator
- Spectrum of the scenario lighting compared to spectrum of the candlelight ageing LED array

- $$\boldsymbol{MMF} = \frac{\int \boldsymbol{E_r}(\boldsymbol{\lambda})\boldsymbol{S_r}(\boldsymbol{\lambda})\boldsymbol{d\lambda} \int \boldsymbol{E_m}(\boldsymbol{\lambda})\boldsymbol{S_m}(\boldsymbol{\lambda})\boldsymbol{d\lambda}}{\int \boldsymbol{E_m}(\boldsymbol{\lambda})\boldsymbol{S_r}(\boldsymbol{\lambda})\boldsymbol{d\lambda} \int \boldsymbol{E_r}(\boldsymbol{\lambda})\boldsymbol{S_m}(\boldsymbol{\lambda})\boldsymbol{d\lambda}}$$
- E_r spectral irradiance of the sun
- E_m spectral irradiance of AM 1.5G
- S_r spectral response of reference cell
- S_m spectral response of test cell

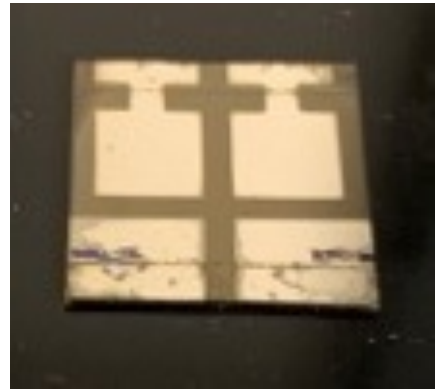
Limitation – poor stability

- Perovskites degrade very quickly. Especially MAPI
- Carbon cells persist for a few weeks
- NiOx/spiro cells are un-usable after a week even in low light
- Encapsulation? More stable perovskite blend? Copper top electrodes?

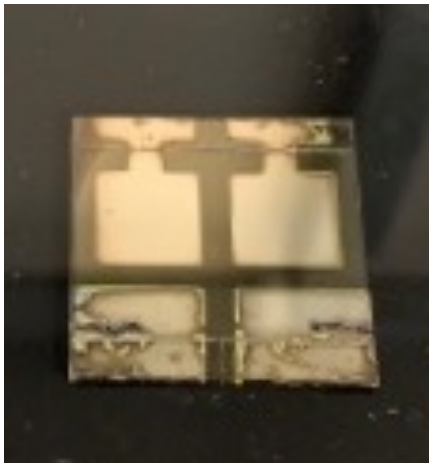
Freshly made



2 days



5 days



14 days