# Degradation in new photovoltaic technologies: how do devices fail?

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## Aims

- Develop and set up a program to control the conditions that affect degradation of solar cells
- Record data showing how the devices begin to fail over a period of 24 hour exposure to sunlight
- Compare 3 different solar cells, each with different amounts of cesium ions added, and determine which device best maintains its efficiency

## Introduction

- A state-of-the-art compound $(FA_{0.83}MA_{0.17})Pb(I_{0.83}Br_{0.17})$, or FAMA for short, made of a new material called a perovskite, can be used to make very high efficiency solar cells. [1] They are extremely simple and inexpensive to produce
- Recent discoveries show that the addition of positive cesium ions ($Cs^+$) into FAMA alters device performance [1]
- Upon addition of $Cs^+$, FAMA crystal lattice contracts. This is due to the significantly smaller radius of $Cs^+$ compared with $FA^+$ [1]

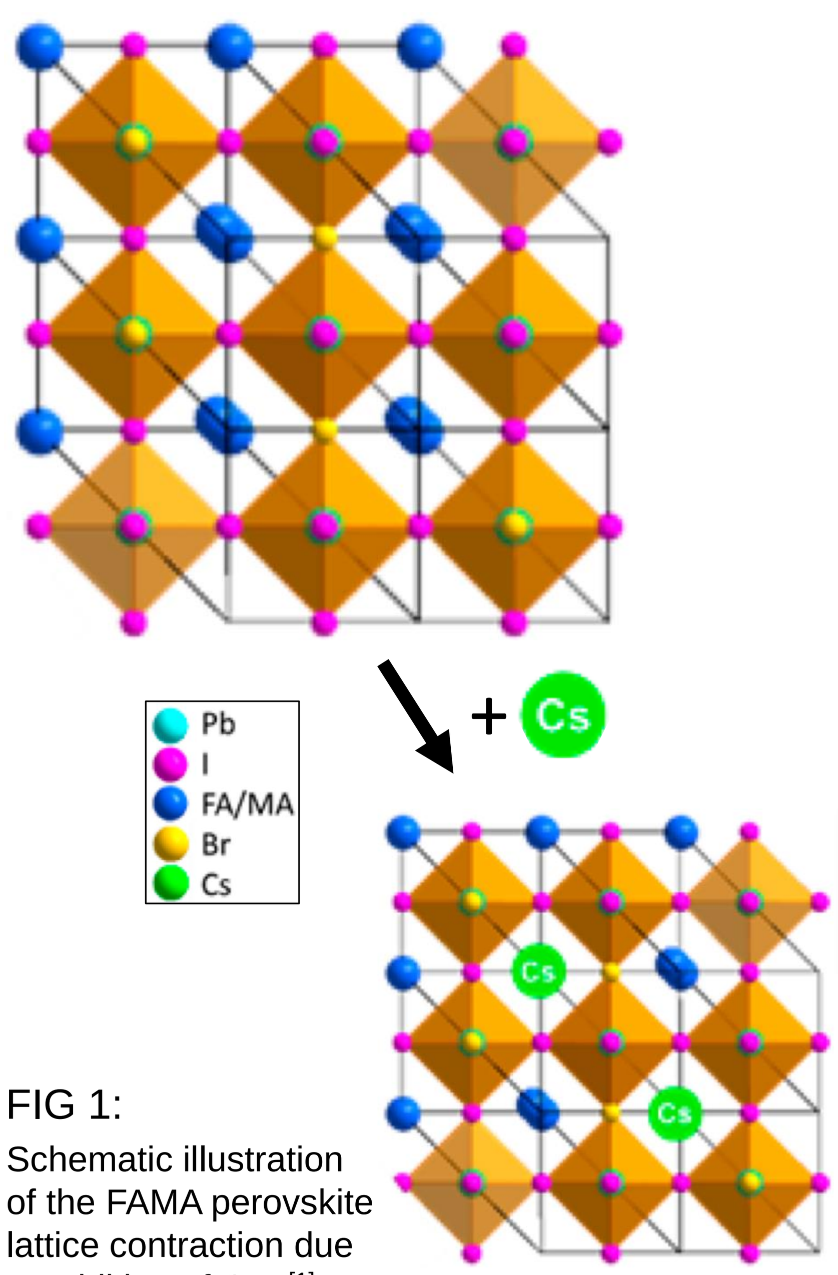


FIG 1:
Schematic illustration of the FAMA perovskite lattice contraction due to addition of $Cs^+$.[1]

- The larger the concentration of $Cs^+$ added, the greater the lattice contracts

## Approach

- The visual programming language LabVIEW was used to create the program, which has the ability to select and deselect specified samples for scanning
- Three different perovskite solar cells:
  **(1) FAMA** **(2) FAMA + Cs5** **(3) FAMA + Cs10**
  were investigated during exposure to sunlight
- A current-voltage (I-V) curve was measured continuously over a of 24 period hours for each of the three samples
- From the I-V curve characteristics, the efficiency of the solar cell at that specific time was calculated, then plotted on an efficiency-time graph, as shown in figure 3.
- To calculate the efficiency, a number of parameters such as short-circuit current ($I_{sc}$), open-circuit voltage ($V_{oc}$), and fill factor (FF) were extracted from the raw data, as illustrated in figure 2.
- The following equations were then used to calculate the efficiency (where P is Power)

$$FF = \frac{I_{mp} \times V_{mp}}{I_{sc} \times V_{oc}} \qquad P_{max} = V_{oc} I_{sc} FF$$

$$\text{Efficiency,} \quad \eta = \frac{P_{maximum}}{P_{input}}$$

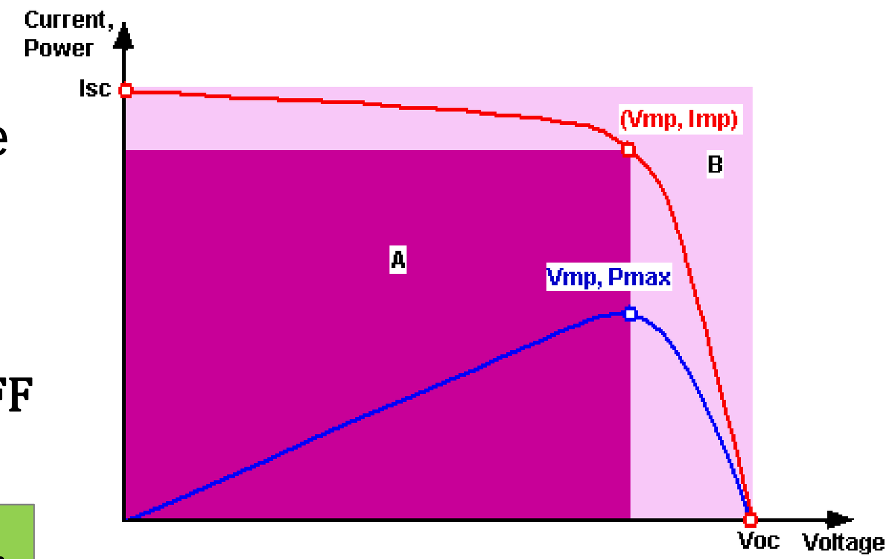


FIG 2: Example I-V curve to illustrate Isc, Voc, Imp, Vmp and Pmax, where Imp and Vmp are current and voltage at maximum power, respectively.[2]

## Results and Discussion

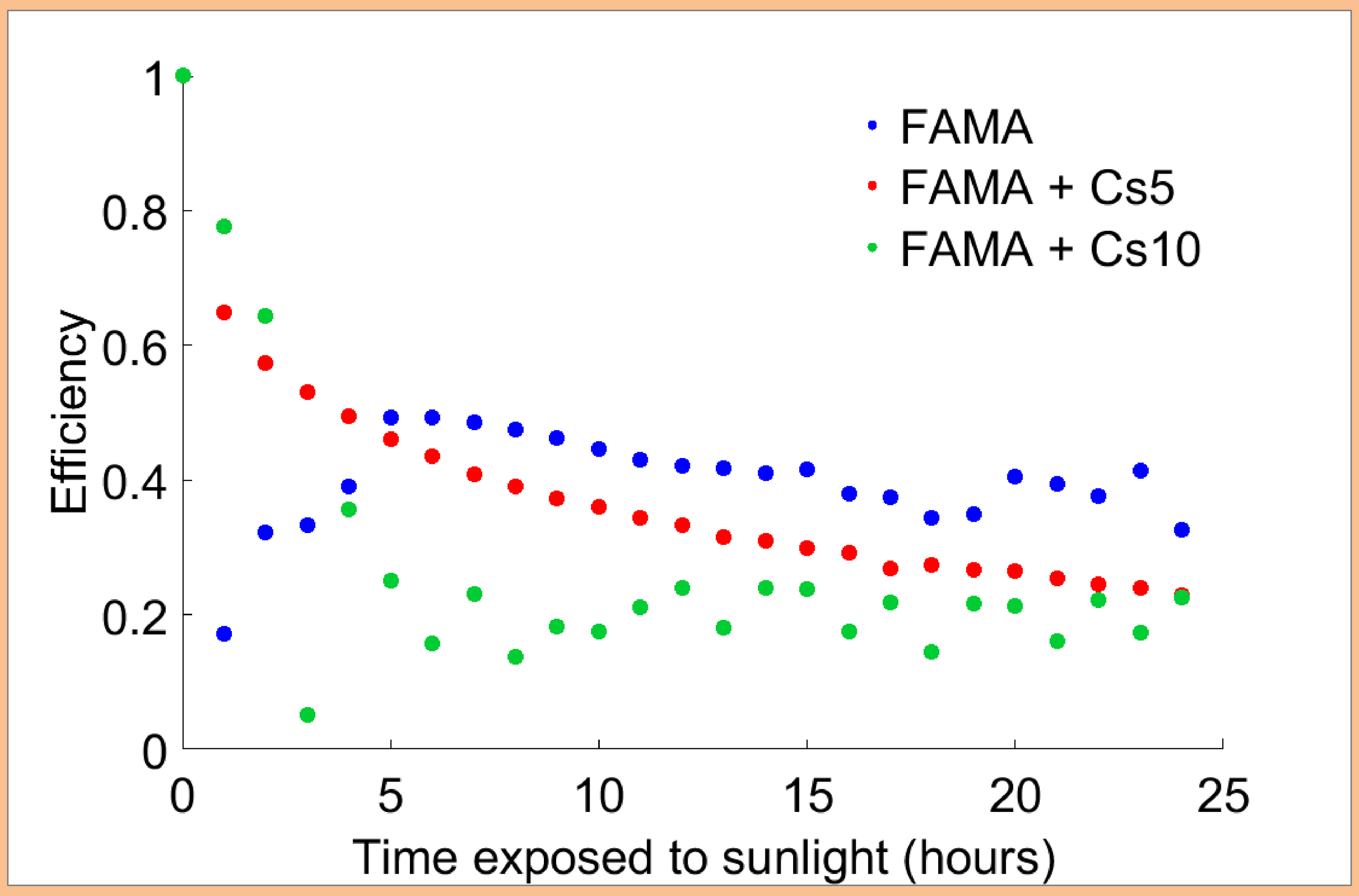


FIG 3: Graph to show the change in efficiency of solar cells exposed to sunlight over a period of 24 hours. Over the 24 hours, the efficiency of all three perovskite devices decreases.

- Efficiency of FAMA + Cs10 perovskite solar cell has the greatest decrease over the 24 hour exposure to sunlight, and pure FAMA has the lowest decrease
- As the addition of $Cs^+$ reduces the radius of the lattice, this suggests that a smaller perovskite lattice leads to a less sustainable solar cell
- Data collected for FAMA and FAMA + Cs10 show many fluctuations in efficiency. This could be due to temperature fluctuations during the scan

## Conclusions

- The LabVIEW program successfully measured solar cell parameters and allowed for monitoring of device efficiency
- After exposing different recipes of perovskites solar cells to sunlight and analysing data collected by the program, it can be seen that over time the efficiency of the devices decreases
- Results show that as more cesium ions are added and, in turn, the size of the perovskite lattice is decreased, the efficiency of the solar cell also decreases.
- However, only one of each perovskite sample was measured. If the experiment was to be repeated, it would be useful to generate multiple scans for a number of the same recipe perovskite

## Acknowledgements

I would like to thank Yinghong Hu of Ludwig Maximilian University of Munich for preparing excellent samples for my research.

I would also like to thank Dr Pablo Docampo for guidance and support throughout the project, and for allowing me this invaluable opportunity.

Finally, I would like to thank Newcastle University for providing me funding for this project.

## References

[1] Hu, Y., Aygüler, M., Petrus, M., Bein, T. and Docampo, P. (2017). *Impact of Rubidium and Cesium Cations on the Moisture Stability of Multiple-Cation Mixed-Halide Perovskites*.

[2] Pveducation.org. (2017). *Fill Factor | PVEducation*. [online] Available at: http://www.pveducation.org/pvcdrom/fill-factor-0 [Accessed 5 Oct. 2017].