Investigating the effects of solar intensity on ionic conductivity in lead iodide perovskite thin films.

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Introduction and Aims

Sunlight, or solar energy, is a clean, renewable source of energy that is extremely important at this moment in time. As climate change is accelerating, demand for energy is rising and non-renewable energy resources are being depleted. However, it can be expensive to manufacture high efficiency solar panels that can tackle this problem. A new type of material called a perovskite can be used to make highly efficient solar panels very easily and at a fraction of the cost. In perovskite solar cells, unlike standard silicon solar cells, perovskites contain ions which hinder the performance of the solar panel and leads to JV hysteresis. The project was designed to observe how the conductivity of the perovskite solar cells is affected by exposing them to different light intensities.

The aim of the project was to extract a value of the ionic conductivity similar to previous papers and to also replicate a graph that showed how ionic conductivity changed different light intensities.

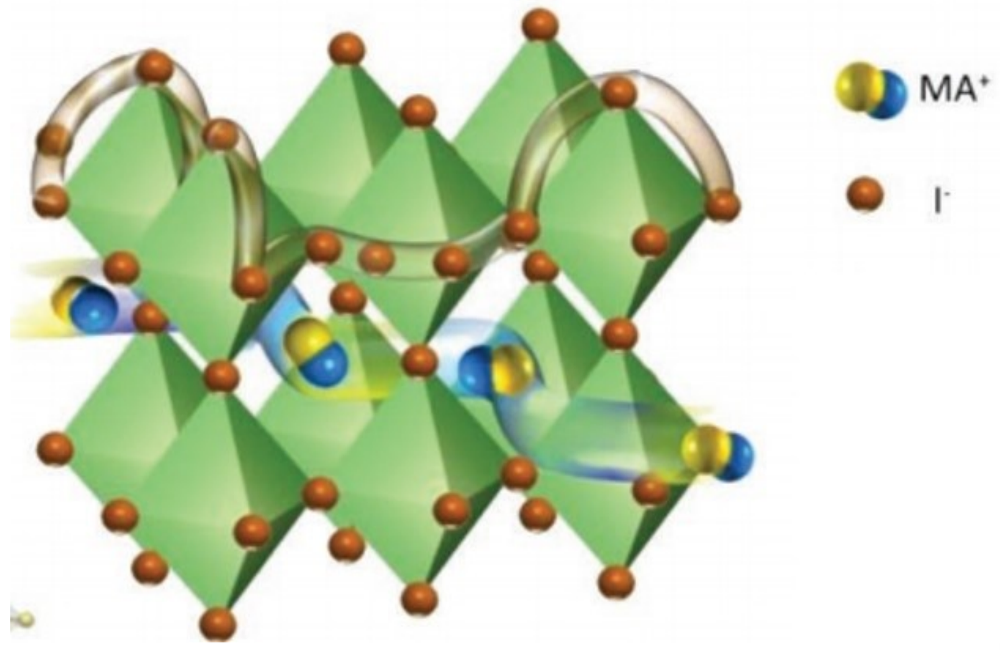
Theory

A perovskite solar cell allows both electrons and vacancies to pass through the structure. Fabrication faults cause vacancies in the structure of the Perovskite. An electrical potential either side of the crystalline perovskite allows for the vacancies to move through the lattice to either side of the system. The motion of vacancies behaves like a current, so as the vacancies are moving and bunching up at either side of the cell, fewer and fewer vacancies are available to move. Therefore, after some period of time where vacancies are bunching up, the current decreases and thus the resistance increases.

After no more vacancies are moving inside the cell, then the resistance will plateau.

The significance of this, is that as the resistance of a solar cell increases, the efficiency of the cell also decreases.

As the light intensity increases on the device, the activation energy decreases. This facilitates the migration of vacancies. So, I was expecting the plateau-level of the cell to decrease as the light intensity increased.



References

[1] Light: Science & Applications (2017) 6, e16243; doi:10.1038/lsa.2016.243 Official journal of the CIOMP 2047-7538/17

Acknowledgements

I would like to thank PhD student Nathan Hill for his significant contribution to the project, for helping with the instrument programming and experimental guidance.

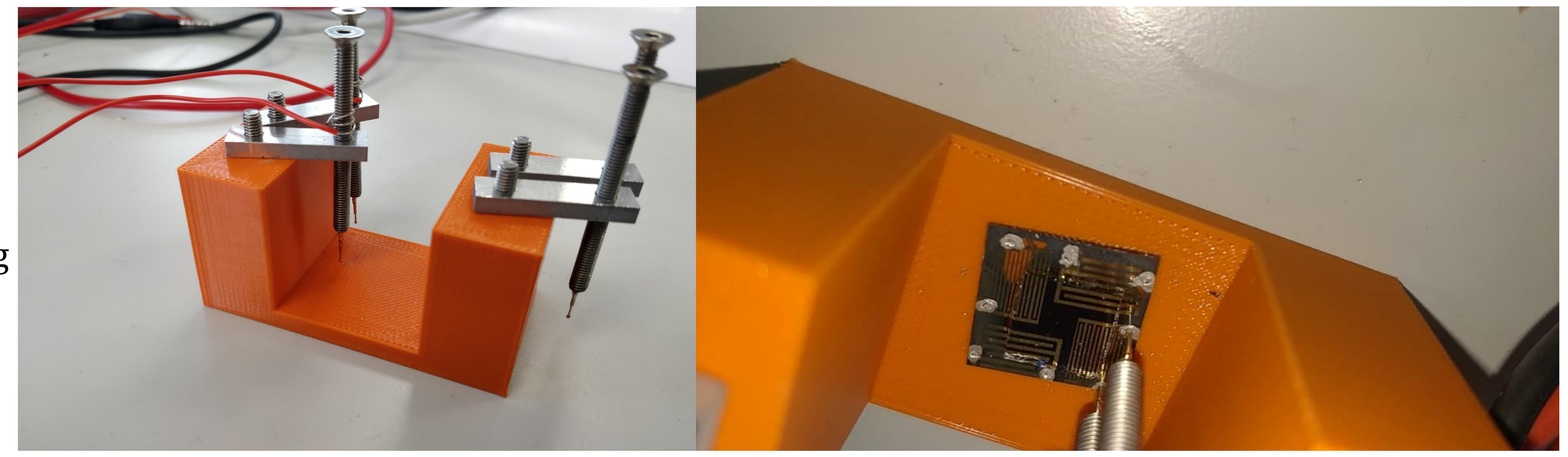
I would like to thank Dr. Pablo Docampo for this theoretical explanations and guidance in understanding the project undertaken.

Finally, I would like to thank the physics office for providing equipment assistance and access to the laboratories.

Instruments

The measurement device was 3D printed using AUTOCAD 2018. Two spring sensors were drilled into the bottom of screws, which could be raised and lowered depending on the sample.

The second image shows how a solar cell would sit in the measurement device.



Results

Figure 1 represents a cell at constant light intensity. This curve shape is exactly what was expected. The value of the resistance at the plateau was also in the same range as scientific literature [1]. This showed that the ionic migration had mostly halted and only the electronic conduction was left after 100s. The conductivity was found to be $3.756 \times 10^{-6} \pm 0.854 \times 10^{-6}$ Sm^{-1} which is consistent with scientific literature, which generally found values between 10^{-6} and 10^{-5}. Figure 2 represents a cell in usual room-light intensity. During the light-yellow phases, an LED of arbitrary light intensity was shone on the cell. The increased light intensity decreases the activation energy for ionic migration to occur. This increases the rate of ionic migration and decreases overall resistance of the cell. This was expected, however, it was unexpected to see the resistance plateau at similar values after shining. It could be cause for further research in my project. Figure 3 shows how different light intensities affect the resistance curve. Greater light intensity reduces the activation energy, which leads to a decreased resistance. The lower the resistance plateau, the greater the light intensity.

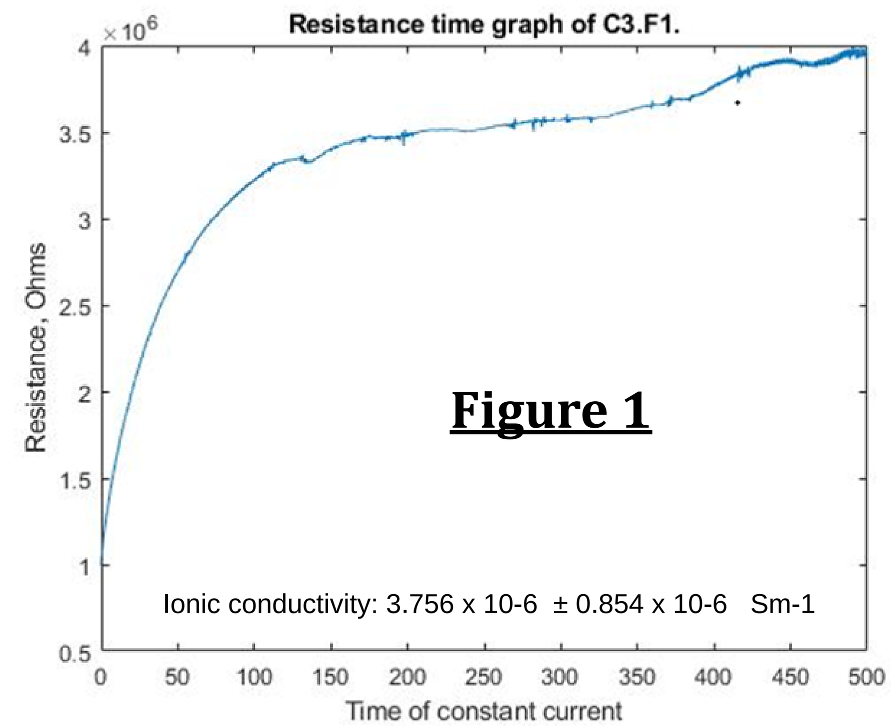


Figure 1

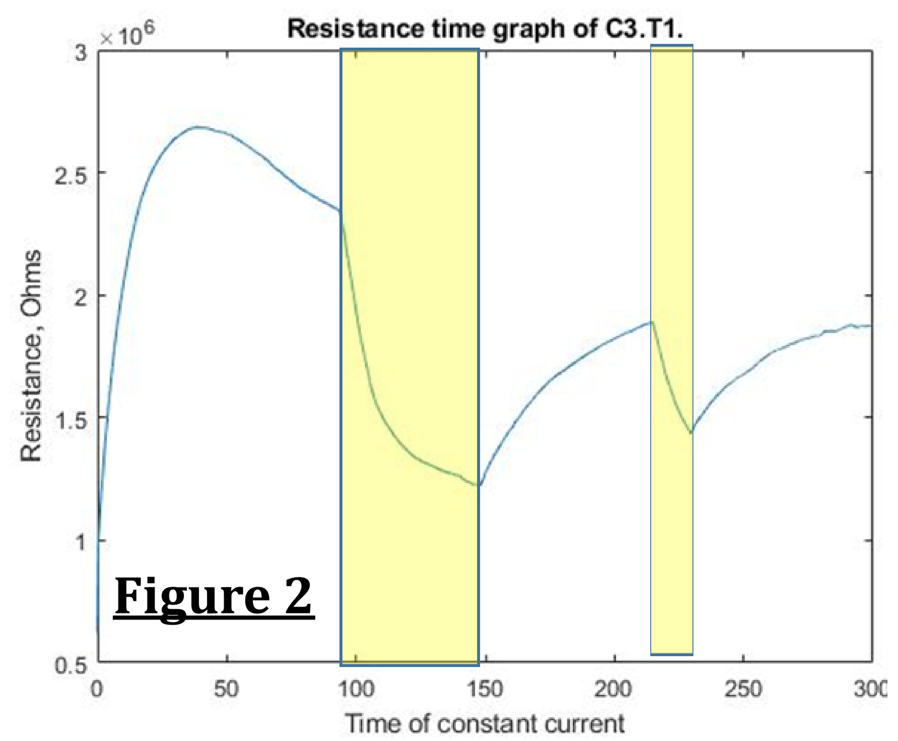


Figure 2

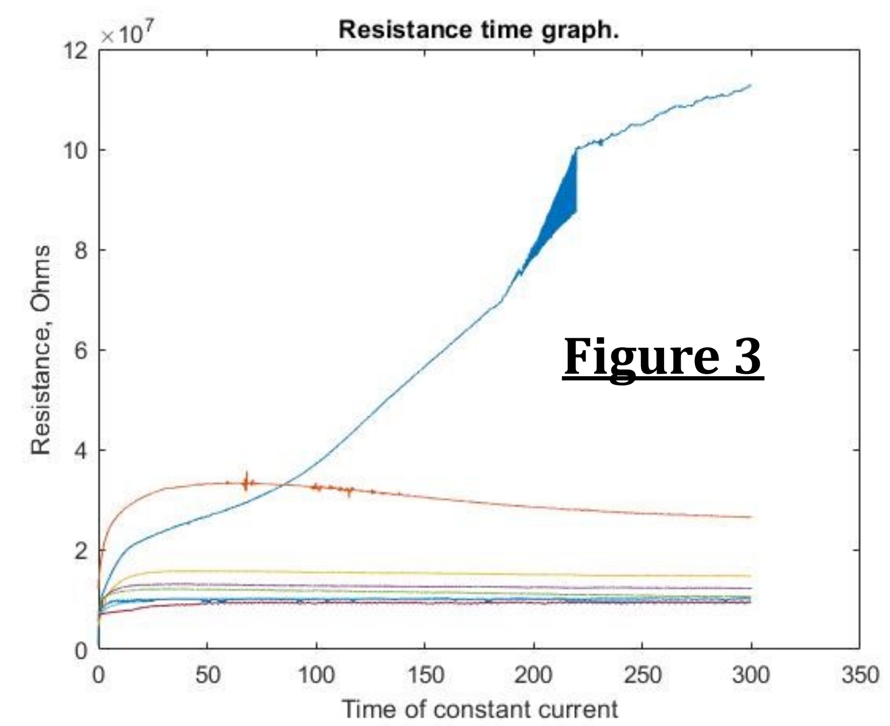


Figure 3

Conclusion

The designed instrument set-up is fully functional. It allows us to conduct J-V sweeps and constant current experiments on Perovskite solar cells. Particularly, the automated data acquisition for varying light intensity.

After processing the data, we consistently found, across multiple cells, that the value for ionic conductivity was roughly between 10^{-6} and 10^{-5} Sm^{-1}, as seen across sources[1].