ND*nano* Undergraduate Research Fellowship (NURF)
2015 Project Summary

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1. Student name: SOORAJ BEN K.R.

2. Faculty mentor name: Prof. PRASHANT V. KAMAT

3. Project title: Perovskite Solar Cells

4. Briefly describe any new skills you acquired during your summer research: Different methods of fabrication of Perovskite solar cells, Usage of Thermal evaporator for metal deposition, Efficiency testing of solar cells.

5. Briefly share a practical application/end use of your research: Perovskite solar cells are expected to be a good competitor in the photovoltaic industry in the future owing to their low cost and high power conversion efficiency.

Begin two-paragraph project summary here (~ one type-written page) to describe problem and project goal and your activities / results:

Organic-inorganic lead halide perovskites have emerged as efficient absorbers in solid state solar cells known as Perovskite solar cells, in the last few years. Perovskite solar cells have become a major competitor in the field of photovoltaics, undergoing rapid evolution in device architecture and fabrication methods and reaching power conversion efficiencies of above 20%. Perovskite solar cells are expected to be a possible competitor in the photovoltaic industry in the future owing to their low costs and high power conversion efficiencies. Stability, low cost and high power conversion efficiency are the factors which largely affects the commercialisation of solar cells. One of the drawbacks of the current perovskite solar cells is the usage of spiro-OMeTAD hole conductor, which is currently more expensive than gold and have a low hole mobility and moreover, being an organic compound, it is expected to be less stable during long term operation. In this scenario, inorganic hole conductors like copper iodide stand chance as alternative hole conductors in solid state perovskite solar cells. CuI is much cheaper, likely to be more stable than spiro-OMeTAD and being transparent, can also be used in inverted perovskite solar cells. Christians et al. has reported CuI hole conductor perovskite solar cells with an

efficiency of 6%. They demonstrated that CuI is much stable and a better hole conductor than spiro-OMeTAD. However, they followed a syringe injection technique for CuI deposition which is tedious and is difficult to scale up. This project focuses on a much simpler 2 step deposition of CuI film, by first depositing metallic Cu followed by conversion to CuI. This method is simple, is expected to produce more uniform films of CuI and can be scaled up easily. The project focuses on designing a suitable strategy for cuI fabrication in perovskite solar cells and produce inorganic hole conductor cells of high efficiency.

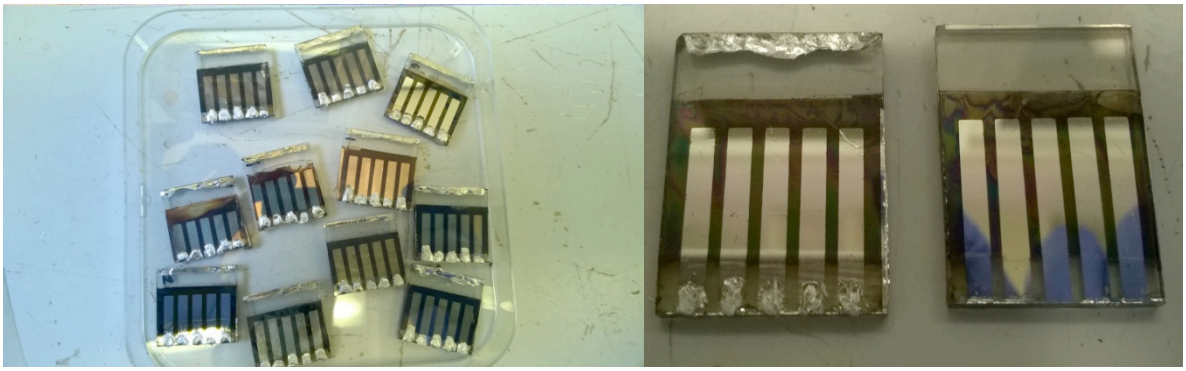
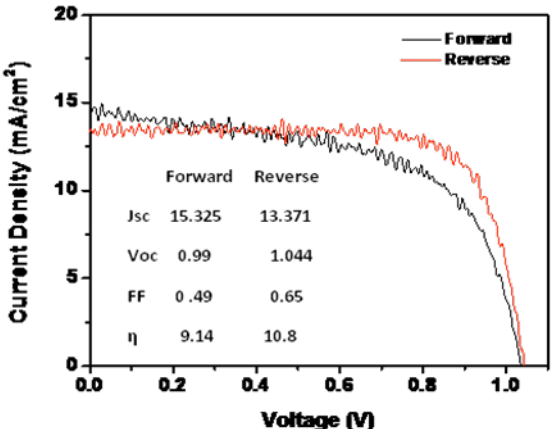
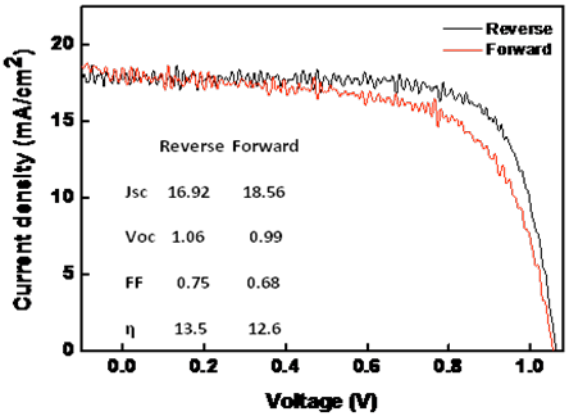


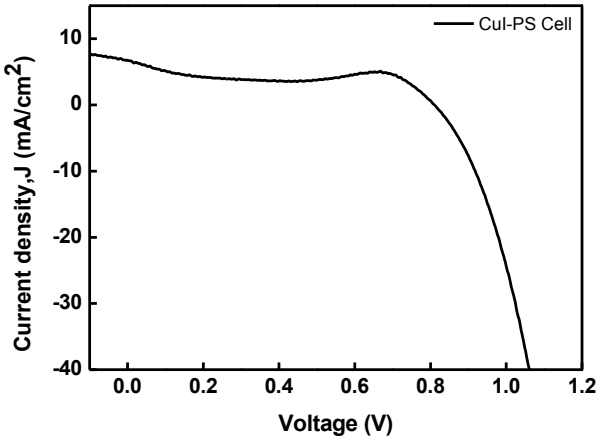
Figure 1 : Perovskite solar cells

Both one step and two step spiro-OMeTAD perovskite solar cells were prepared with a maximum attained efficiency of 13.5 % in one step cell and 10.8% in case of 2 step solar cell. CuI based perovskite solar cells were prepared using different approaches. Exposing Cu film to both MAI and I_2 vapours didn't give a transparent CuI film, hence the method was discarded. Both dipping in and spin coating of I2 solution in chlorobenzene formed transparent CuI films but the method seemed to destroy the perovskite solar cells. The entire cell turned yellow from brown, after dipping in I_2 solution indicating degradation of perovskite. So far, the best method of deposition was found to be dipping the Cu film in a ~100mg/mL solution of MAI in 2-propanol for around 15 minutes, which yields a transparent CuI film without visibly destroying the perovskite layer. The maximum efficiency attained in such cells is 3.4%.The efficiency of CuI based perovskite solar cells can definitely be improved by optimising the deposition techniques, and since CuI can be more stable than the organic spiro-OMeTAD counterpart, it still can become a better hole conductor in perovskite solar cells and hence more research has to be done in this regard.





Graph1: J-V curve for two step champion solar cell; Graph2: J-V curve for one step champion cell



Jsc - 6.75
Voc – 0.81
FF- 0.62
η - 3.4

Graph3: J-V curve for CuI-perovskite solar cell.