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Techno-economic analysis based on demonstrated silicon perovskite tandem cells

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Background

Tandem cells have been proposed as a future step in industrial photovoltaic module technology (Green, 2017), with an improved efficiency potential compared to single junction devices. However these more complex structures are expected to be more expensive. Under the right conditions of performance and cost, tandem cells could reduce the system level cost in $/W, leading to a lower levelized cost of electricity (LCOE).

The perovskite top and silicon bottom tandem (PST) cell has gathered interest recently, as the perovskite single junction cell efficiency has increased rapidly to over 20%, and the perovskite material bandgap s can be tuned en suit the top cell of a tandem structure. To date, such tandem structures have achieved in excess of 25% efficiency, albeit on small area cells of approximately 1cm2.

While there remains much work to scale up these results to large areas and further improve the efficiency, there is also benefit in analysing the cost of these structures in order to both inform the research community of the commercial potential of this technology as well as to identify key financial and technical barriers that must be overcome in order to commercialise this structure.

Within the area of PST cells, there are many variations to consider. Within the literature, (i) the type of silicon bottom cell can vary between a homo-junction structure (the dominant structure used for producing silicon cells commercially) and the hetero-junction structure (with higher efficiency potential but currently higher cost), and (ii) the two cells can be interconnected monolithically in a 2-terminal configuration, or can be separated electrically into two cells in parallel as a 4-terminal configuration.

In this work, two demonstrated 2-terminal PST results using a homo-junction bottom cell are analysed to estimate the cost and cost drivers for the state of the art for this type of PST cell. The first structure was demonstrated by UNSW (Zheng, 2018), achieving a stabilised 17.1% efficiency on a 16 cm^2 cell. The second structure was demonstrated by ANU (Wu, 2017), achieving a much higher 22.5% efficiency, on a smaller 1cm^2 area cell.

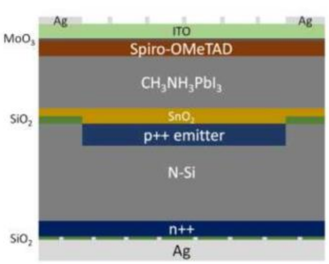


Fig 1. Demonstrated UNSW Structure

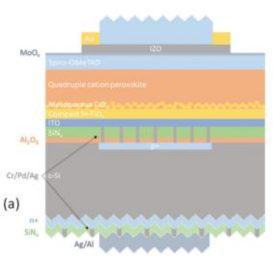
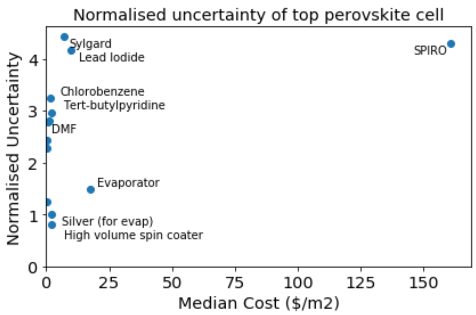


Fig 2. Demonstrated ANU Structure

The cost analysis method has been previously reported (Chang, 2018). It incorporates uncertainty into the cost model, which allows a techno-economic analysis of early stage technologies without excessive use of resources to collect highly accurate data.

Initial Cost Result – demonstrated UNSW sequence

Examining the cost structure of the demonstrated perovskite top cell (Figure 3), the dominant cost driver is the SPIRO HTM layer, which is prohibitively expensive (a c-Si module sells for less than $100/m2). This directs researchers to replace this material with an alternative. If this can be done, the next level of high cost drivers have also been identified.



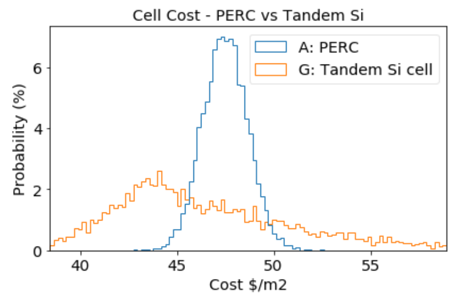


Fig 3. Cost components perovskite cell

Fig 4 Cost of Si cell compared to PERC

Examining the cost results of the demonstrated bottom Si cell (Figure 4), it shows that the particular processing used in this demonstration has a similar cost structure to a standard PERC cell, with the potential to be slightly lower cost. This is a positive result, showing that a good efficiency result could be obtained without excessively expensive changes to the bottom cell structure.

Further Cost Results – demonstrated ANU sequence and variations in sequences

An analysis of the ANU structure (Wu, 2017) is currently underway on the structure shown in Figure 2, and will be completed by the time of the conference.

On completion of the cost analysis for both demonstrated sequences, a number of variations of these sequences will be proposed and analysed. This will help identify the importance and impact of process improvements that are expected or planned by both groups.

Conclusions

The conclusions and implications of this work are to be finalised, but are expected to include:

- Key cost drivers for the UNSW structure.
- Key cost drivers for the ANU structure.
- Projected costs of improved UNSW and ANU sequences.

References

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