Driving Increased Efficiency and Reliability in Silicon Photovoltaics – From Ingots to Modules

Project results and lessons learnt

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Executive Summary

This project aims to develop new techniques and tools to identify the most important loss and degradation mechanisms in industrial photovoltaic technology, extending along the value chain from silicon ingots, wafers, cells and through to the final modules. These new methods will help to pinpoint key loss mechanisms, and lead to new strategies to avoid them. This will in turn increase the efficiency and reliability of photovoltaic modules, leading to further cost reductions of solar electricity for consumers in Australia and worldwide.

A primary focus of the project has been the development of novel luminescence-based tools for rapid and accurate inspection of ingots, wafers, cells and modules, in conjunction with BT Imaging, an Australian metrology company that services the global PV industry. We are also working closely with Jinko Solar, the largest manufacturer of PV modules worldwide, to develop improved silicon ingots and wafers using low-cost casting methods, and demonstrate high efficiency solar cells on these materials with industrially-compatible processing. We also collaborate with some of the leading solar energy institutes worldwide, including Fraunhofer ISE in Germany and the National Renewable Energy Laboratory in the USA, to explore new possibilities for improved characterisation of silicon materials and solar cells. The project has been very successful to date, with a number of exciting new methods for wafer, cell and module inspection being developed and demonstrated, together with our industry partners.

Project Overview

Project summary

The project aims to develop and demonstrate a range of new techniques and tools to identify the key causes of avoidable efficiency loss in silicon photovoltaic modules. The project extends along the value chain, from silicon ingots, through to wafers, cells and modules, since defects and degradation mechanisms at all of these stages can affect the final module performance. Advanced luminescence-based methods are central to many of the innovations in this project. These allow rapid, contactless, and high resolution imaging of the relevant properties. These techniques will also be applied to low-cost multicrystalline and cast-monocrystalline silicon wafers to demonstrate the potential of these materials for high efficiency cells and modules.

Project scope

The motivation for this project is to reduce the impact of defects and degradation mechanisms in silicon solar cells and modules. These loss mechanisms are complex and multi-faceted, and the tools currently available are limited in their ability to accurately identify and quantify these losses. This project aims to address this gap by developing new methods and tools, mostly using advanced luminescence-based characterisation, which can be applied at the relevant stages in production and in the laboratory. The project also aims to apply some of these methods to low-cost cast silicon materials, in order to assess their potential for high efficiency solar cells in production.

Outcomes

To date, the project has developed and demonstrated a range of new or improved methods for identifying loss and degradation mechanisms in silicon solar cells at numerous points along the production chain. Some of these are now being tested in production lines with our industrial partners, to assess their potential for commercialisation. These methods allow more rapid or accurate characterisation of key loss mechanisms, in turn helping to increase throughout or yield, and therefore reduce costs. Innovations arising from this project so far are described in more than 50 scientific publications, and the project is well on track to meet its overall objectives.

Transferability

The innovations in this project are applicable to the global photovoltaic research community and industry. Our approach to sharing the knowledge and outcomes from this project has been two-fold. Firstly, more fundamental advances that are not of direct, short-term commercial interest are published in the scientific literature, to enable them to be accessed by the global photovoltaic research community. On the other hand, innovations with clear potential for near-term commercialisation are being further developed and tested with our project partners, to assess their value and feasibility in the market.

Conclusion and next steps

This project is still at its mid-point. Our next steps are to continue developing the most promising of the new methods and tools we have created in this project, and then to work with our project partners to commercialise the most suitable innovations, while publishing others in the literature, to ensure they can be used by the photovoltaic research community.

Lessons Learnt

Lessons Learnt Report: Project consortium

Project Name: *RND017 – Driving Increased Efficiency and Reliability in Silicon Photovoltaics – From Ingots to Modules*

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Solar PV
State/Territory:	ACT and NSW

Key learning

We have learnt that establishing and maintaining a well-balanced set of project partners, both commercial and institutional, is critical to ensure that we are able to develop the most promising methods and tools, and that we have a clear path to commercialise those with commercial potential. Having some overlap between our partners' interests and capabilities is desirable, in order to avoid excessive reliance on a single partner in case they cannot deliver on their commitments. However, this should be balanced against the need to avoid unwanted internal competition within the project. Maintaining trusting and open communications with project partners is also critically important.

Implications for future projects

In future projects we would aim to establish a set of project partners with whom we have already established strong relationships, and for whom the potential benefits of the project are clear.

Lessons Learnt

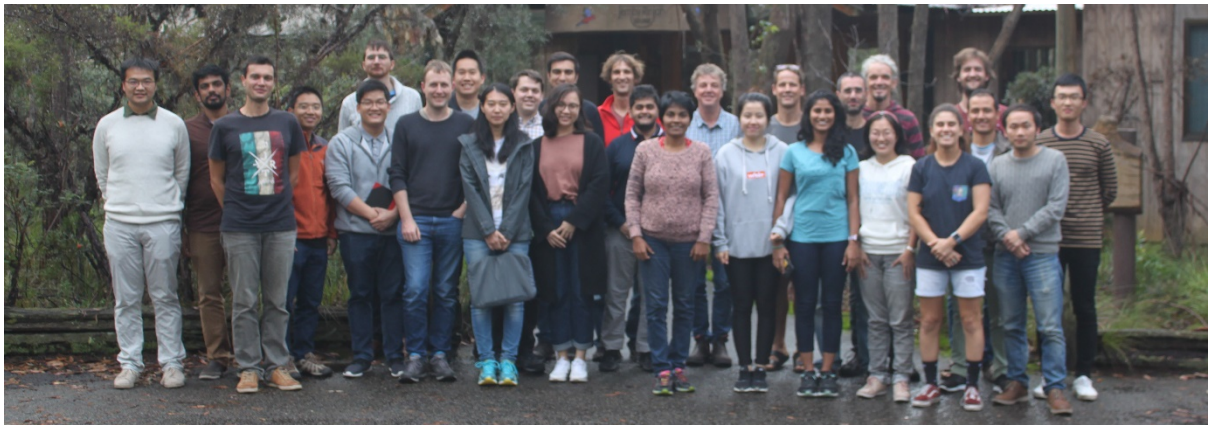
Lessons Learnt Report: Project communications

Project Name: *RND017 – Driving Increased Efficiency and Reliability in Silicon Photovoltaics – From Ingots to Modules*

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Solar PV
State/Territory:	ACT and NSW

Key learning

Providing effective ways for our project partners to work together is critical for the success of a multi-partner project such as this. In particular, the two primary teams at ANU and UNSW have developed very effective channels for communication, which have built mutual trust, and enabled many parallel collaborations within the project. The most important method for establishing and maintaining this communication has been our annual project workshop. The latest of these was held for 3 days in the Blue Mountains in March, 2019, and was attended by 30 project-related staff and students from ANU and UNSW, and some visiting researchers. We have found these workshops to be a very powerful way to build deep and trusting connections between researchers, which then leads to more meaningful collaborations.



Implications for future projects

In future projects we would aim to further expand this aspect of the collaborative work between ANU and UNSW, by broadening the workshop to include researchers from other related projects at both universities. We believe this would further strengthen the connections between our groups, and lead to more effective outcomes across many projects.