



Identifying and understanding the performance limitations for standard commercial solar cells followed by the identification and implementation of solutions to these limitations

Project Name: [Overcoming the fundamental performance limitations of commercial solar cells](#)

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Solar PV
State/Territory:	New South Wales

Key learning

Identifying and understanding the performance limitations for standard commercial solar cells followed by the identification and implementation of solutions to these limitations.

A detailed analysis of existing commercial solar cells based on screen-printing enabled the performance limitations of this technology to be identified. The majority have aluminium alloyed rear contacts covering the entire rear surface that now primarily limit achievable efficiencies. Such contacts provide poor rear surface passivation and poor internal reflection of light trapped within the silicon. The next greatest loss mechanism arises through the poor quality of the silicon wafers that are used commercially to keep costs low. The third largest loss mechanism results from the nature of screen-printed metal contacts on the light receiving surface where lines are wider than optimal due to the screen-printing process and the silicon surface needs to be heavily doped with phosphorus to allow good electrical contact to be formed between the metal and the silicon.

Through the development and implementation of solutions to these limitations, new world record efficiencies were achieved as a result of these technological advances. Several patents were also secured due to the innovativeness of the developments.

Implications for future projects

Future projects such as ARENA RND068 are able to take advantage of all the above technological advances. The corresponding IP associated with these developments is all Australian owned and therefore available to Australian industry and researchers.

Knowledge gap

A range of areas for further beneficial and novel work have been identified and funding sought for a future project. This future work particularly relates to fully exploiting the new hydrogenation technology, adding the latest developments for the plating and contact formation into commercial technology and the development and demonstration of a particularly innovative approach for designing and fabricating the new rear surface and contacting designs. The new project commences in July 2015 and is designated ARENA RND068.

Background

Objectives or project requirements

The project was aiming to identify the main weakness in the most common current commercial solar cells and then find ways of overcoming these weaknesses to improve the efficiencies of solar cells. The development of the new plating technology and the corresponding design of commercial tools for the technology manufacturing were particular objectives for overcoming the limitations imposed by the screen-printed contacts. An important objective also part focused on minimising the losses associated with silicon wafers from which the solar cells were made. Through this, new techniques were developed for controlling the charge state of the hydrogen atoms that were diffused into the silicon, with the important benefits that this allowed improved mobility and reactivity for the hydrogen atoms. Perhaps just as importantly, the aim was to overcome the substantial losses associated with the rear design of standard solar cells.

Process undertaken

Solutions to all three areas of limitation were formulated and implemented by:

1. Using a passivating dielectric layer on the rear surface as an interfacial layer between the silicon and the aluminium. This required laser patterning of the dielectric in localised areas to allow the aluminium to make contact to the silicon but solved both problems in terms of eliminating recombination at the rear surface of the silicon and improving the internal reflection of the rear surface. Multiple dielectrics such as SiNx and AlOx were all shown to be suitable for these purposes.
2. Using new hydrogen passivation technology to improve the wafer quality as described in the document focusing on the lessons learned in conjunction with hydrogenation.
3. Replacing the screen-printed contacts with plated contacts formed by patterning the surface dielectric layer with a laser and then plating nickel and/or copper to the exposed silicon. This allows much narrower lines to be formed and can be easily implemented whereby the silicon is only heavily doped immediately beneath the metal contact. New plating baths were designed and fabricated for the implementation and demonstration of the new innovative plating technologies developed at UNSW.

Supporting information

Z. Wang, P. Han, H. Lu, H. Qian, L. Chen, Q. Meng, N. Tang, F. Gao, Y. Jia, J. Wu, W. Wu, H. Zhu, J. Ji, Z. Shi, A. Sugiarto, L. Mai, B. Hallam, and S. Wenham. "Advanced PERC and PERL production cells with

20.3% record efficiency for standard commercial p-type silicon wafers", Progress in Photovoltaics: Research and Applications, Vol. 20, pp. 260-268, 2012