HYDROGENATED BIFACIAL PERL SILICON PV CELLS WITH LASER DOPING AND PLATED CONTACTS

Project results and lessons learnt

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Executive Summary

Record 22.6% efficient PERC solar cells use screen-printing, requiring expensive silver and aluminium pastes. PERC cells also have significant metal/silicon interface recombination, high metal shading losses and are generally plagued by light-induced degradation (LID), which significantly affects performance and therefore increases costs. Transforming PERC into PERL in the lab through improved metal/silicon interface doping, increased efficiencies from 22% to 25%. This project will address the performance and cost limitations of current PERC technology by enabling the transformation of industrial p-type solar cells to a PERL structure using proven technologies. The aim of the project is to develop a breakthrough low-cost, high-efficiency PERL cell technology and innovative, high-throughput commercial production processes and equipment.

This project will build on the successful outcome of three ARENA projects to develop the next generation high-efficiency solar cell. The work in the first 18 months of the project has focused on the development of integration of the three technologies. This includes the development of an AlOx based p-type laser doping process, the following metal plating process, the incorporation of advanced hydrogenation at different cell process steps for the passivation of laser-induced and light-induced defects, and PERL cell fabrication using commercial grade p-type wafers. A 19.8% efficient cell device integrating the three technologies has been made.

Project Overview

Project summary

The first stage is to integrate the three technologies and fabricate laser doped and hydrogenated Passivated Emitter and Rear Cell (PERC) and Passivated Emitter Rear Locally-diffused (PERL) cell devices with plated contacts.

One of the focuses is to implement the selective laser doped emitter technology on both the front and rear surfaces to create a bifacial PERL cell structure for optimum current generation and collection. Different lasers have been tested to develop suitable conditions for the selective laser-doping process. Smooth laser doped lines with minimal laser-induced damage have been achieved after optimization.

Plating has been developed together with the laser doping process for metal deposition. To avoid using expensive silver and aluminium screen-print paste, low temperature metal deposition by light induced plating for laser doped bifacial PERL cell has been developed. The laser doping and self-aligned plating form closely placed narrow fingers with significantly reduced shading losses. Smooth and uniform metal deposition on both the n-type surface and p-type surface has been achieved.

Advanced hydrogenation technology, which controls the charge state of hydrogen, has been integrated into the cell fabrication process. It improves the quality of commercial grade silicon wafers, eliminates light-induced degradation (LID) and passivates laser induced defects introduced during the laser doping process.

Project scope

Record 22.6% efficient PERC solar cells use screen-printing, requiring expensive silver and aluminium pastes. PERC cells also have significant metal/silicon interface recombination, high metal shading losses and are generally plagued by light-induced degradation (LID), which significantly affects performance and therefore increases costs. Transforming PERC into PERL in the lab through improved metal/silicon interface doping, increased efficiencies from 22% to 25%. This project will address the performance and cost limitations of current PERC technology by enabling the transformation of industrial p-type solar cells to a PERL structure using proven technologies. The aim of the project is to develop a breakthrough low-cost, high-efficiency PERL cell technology and innovative, high-throughput commercial production processes and equipment.

Outcomes

We have successfully incorporated the laser doping technology, advanced hydrogenation technology and bifacial plating technology into cell fabrication processes. We have fabricated working laser doped PERC and PERL devices with plated contacts and passivated using advanced hydrogenation. Working cell device incorporating the three technologies with 19.8% efficiency has been achieved.

The promising result indicates we are well on track to develop a breakthrough low-cost, high-efficiency PERL cell technology and innovative, high-throughput commercial production processes and equipment.

Transferability

The PV industry is shifting toward the PERC technology, while the top manufacturers are exploring the possibility of bifacial cells. Plating is a preferred approach for bifacial solar cells due to the narrow line-widths achievable, and the avoidance of silver consumption. With the main hurdle of access to high throughput plating equipment resolved by this project, it is expected manufacturers will have great incentive to licence the technology for the fabrication of bifacial solar cells.

Metal plating has many advantages over traditional screen-printing techniques. It is capable of forming narrower metal fingers to reduce shading loss and does not require expensive silver. It is expected that future high-efficiency cell technologies will employ plating to form metal contacts. The availability of commercial plating equipment at the conclusion of this project will facilitate the commercialization of future generations of high-efficiency solar cells using plating technologies.

Conclusion and next steps

We have successfully achieved the goal of the first stage of the project of incorporating the three key technologies. Promising initial cell efficiency of 19.8% has been achieved. The next step is to further develop the cell technology, analyse the cell efficiency losses and optimize each fabrication process to improve cell efficiency.

Lessons Learnt

Lessons Learnt Report: Hydrogenation of solar cells with plated contacts

Project Name: HYDROGENATED BIFACIAL PERL SILICON PV CELLS WITH LASER DOPING AND PLATED CONTACTS

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

Key learning

We have learnt that the standard advanced hydrogenation process for screen printed cells can work on bifacial PERL cells with laser doping and plated contacts. However, instead of applying the hydrogenation process on finished cells with screen printed contacts, it should be applied before or after laser doping, or during nickel sintering. This is because the thermal expansion coefficient of silicon and copper are quite different. Applying hydrogenation after copper plating will affect the contacts causing them to peel off silicon, reducing fill factor and hence cell efficiency.

Implications for future projects

Solar cells with plated contacts can all benefit from the advanced hydrogenation technology such as heterojunction cells or other low processing temperature cells. The passivation process not only eliminates light induced degradation, other defects like laser induced defects, hydrogen induced defects can all be passivated as well.

Knowledge gap

At the moment advanced hydrogenation and nickel sintering are two different processing steps. We will research and develop a new process that combines the advanced hydrogenation process with nickel sintering process into one processing step. Eliminating one processing step will simplify the cell fabrication and reduce cost.

Background

Objectives or project requirements

The aim of the first 18 months is to develop and integrate the three technologies together to fabricate working cell devices. These objectives include:

- a high-efficiency emitter process for bifacial solar cells that enables plating on the n-type contact without any ghost plating issues

- Fabrication of a working PERC device demonstrating the successful integration of the three technology areas of laser doping, plating and advanced hydrogenation

- Demonstration of a working bifacial PERC device incorporating plated contacts on both surfaces

- Fabrication of a working PERL solar cell device

- Achievement of <4% LID efficiency loss using standard industry testing on a cell with plated contacts

Process undertaken

For the hydrogenation process, at this first stage we needed to see:

- If the standard advanced hydrogenation for screen printed cell can work on the bifacial PERL cells with laser doping and plated contacts

- How well it can passivate laser induced defects and eliminate LID

- At which stage of the cell fabrication it should be incorporated in

- Identify if there's a more efficient way of applying the advanced hydrogenation technology and optimize it for the bifacial PERL cells with laser doping and plated contacts

We have incorporated the advanced hydrogenation process at different stage of the cell fabrication including before laser doping, after laser doping, after nickel plating and after copper plating. Hydrogen passivation can successfully passivate laser induced defects and eliminate LID efficiency losses to less than 1.5% relative. However, we found that it should be applied before the copper deposition because applying it after can cause copper to peel and destroy the contacts. We have identified that it is possible to combine advanced hydrogenation and nickel sintering into one process step. In the next stage we will look into optimizing the advanced hydrogenation process for bifacial PERL cells with laser doping and plated contacts and explore and develop the combining of advanced hydrogenation and nickel sintering.