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Technology transfer – challenges and learnings – A SIRF case study

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Introduction

Like other research institutes around the world, UNSW is developing new photovoltaic (PV) technologies and many ideas have the potential to be commercialised. The time frames between an idea being formulated, to it being proven in the lab, and then to being commercialised can be very long. For example, the PERC cell idea was first conceived in 1983 [1], the first paper to report the demonstration of this technology was in 1989 [2], but it took two more decades before high volume production [1]. Since then, PERC manufacturing capacity has now become the most dominant cell technology in the PV industry.

The Solar Industrial Research Facility (SIRF) was founded in 2011 with the aim to speed up technology transfer and commercialisation by bridging the gap between the laboratory and industry. When a new technology or process is developed, there are milestones that are visible to the outside world – patents filed, papers published and finally a commercial product. Behind the scenes, there is much more happening. For example, the development and optimisation of prototype processing tools of progressively increasing size, complexity and throughput. The SIRF assists researchers through this process with advice on tool design and quick tool fabrication through its strong links with industry, assisting in running scale and volume tests, and helping with cost benefit analysis of new processes. This paper uses the development of the advanced hydrogenation technology as a case study.

Light-induced degradation (LID) of p-type Czochralski (Cz) solar cells has long been a known problem in the PV industry. In 2012, UNSW developed a new idea (known as the advanced hydrogenation technology (AHT) [3]) to passivate the boron-oxygen defects through controlling of the charge state for the hydrogen atoms in silicon. In this case study, we will discuss the challenges encountered at each phase of the development (Figure 1), together with the solutions and learnings as the technology was demonstrated.

Challenges and solutions

1. *Phase 1 – Proof of concept*

We will briefly describe the research lab development phase, which occurred before the SIRF was directly involved. The challenge in proving the concept was to find a well-controlled varying-intensity light source (Figure 1(a)). To meet this requirement, a high-powered class 4 laser tool was set up to provide intensity up to a hundred suns (Figure 1(b)). This highly versatile lab tool successfully allowed the researchers to gain a deep understanding of the science behind hydrogen charge state control and working AHT processes were demonstrated. Two main limitations existed with this approach: 1) small laser spot size meant limited sample size; and 2) a perception that this method would be too expensive and difficult to implement in manufacturing because of safety concerns. To demonstrate its significant application in manufacturing, AHT needed to be demonstrated on full size samples (6”) using a safe and low cost approach.

2. *Phase 2 – Prototyping for tool and process development*

In 2016, the AHT was transferred to the SIRF for the next phase, the aim of which was to investigate the impact of AHT on the performance and stability of screen printed Cz cells fabricated on the production lines of several industry partners. Several prototypes were built in the SIRF using low-cost LEDs (Figure 1 (c)-(e)) – from a single-LED tool to evaluate LEDs as a suitable illumination source– to an LED array to implement the AHT to solve LID in full-sized Cz commercial-screen-printed cells. The main challenges included: 1) sourcing high-powered LEDs from the market; 2) maintaining light uniformity over the entire 6” wafers; 3) managing heating and cooling rates in the samples. As the researchers and SIRF prototype and equipment engineers worked closely together, the short feedback loop enabled time-effective improvements in both the prototypes and the AHT process, achieving the goal within a few months [4].

3. Phase 3 – Technology transfer to industry (Pilotline Scale Demonstration to Mass Production)

To enable a smooth transfer of a technology to industry, at some point it is necessary to develop industrial scale equipment with high production throughput. Whilst it may be tempting to leave this to industry, researchers can have a key role in this. In October 2016, the AHT had reached the stage where an industrially relevant tool needed to be developed. The research team and SIRF team collaborated with industry through equipment suppliers in China to integrate the technology into two new commercial AHT tools. One was LED-based, developed in collaboration with the Asia Neo Tech (ANT) Industrial Company, and the other was laser-based, developed with the DR Laser company. The combination of UNSW team know-how (gained through developing and using the prototypes) and the speed of the industry partners led to the fabrication and installation in SIRF of two commercial hydrogenation tools within half a year (Figures 1 (f) and (g)). One challenge here was to ensure the tools met the necessary Australian safety standards, since tool fabrication occurred in China. This was addressed by having SIRF personnel working closely with both partners from the tool design phase through to tool completion. Both of these new industrial scale tools have since been installed in industrial solar cell manufacturing lines.

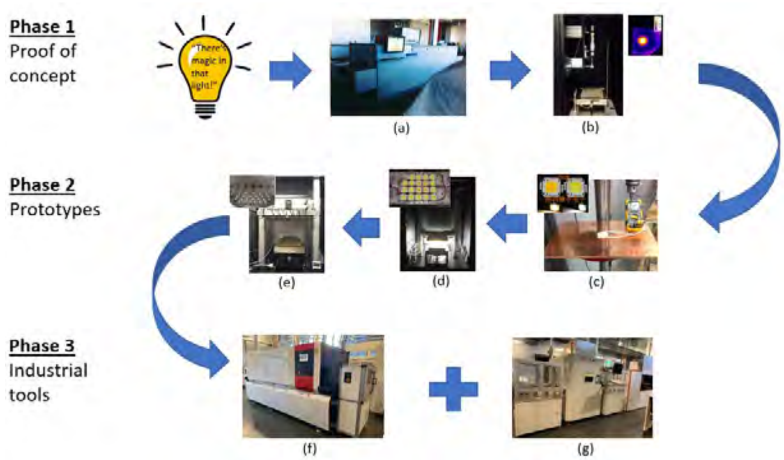

Figure 1. Toolset in various developmental stages of the AHT. (a) Schmidt belt-furnace; (b) laser prototype for small samples; (c) LED prototype for small samples; (d) LED prototype for 6“ samples; (e) final LED prototype for 6" samples; (f) ANT tool; (g) DR Laser tool.

References

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