Solar PV technology trends for 2016

Finlay Colville, Head of Market Intelligence, Solar Media

ABSTRACT

Solar photovoltaic manufacturing is benefiting today from increased allocations by leading producers for capex into new facilities and technologies. Capturing these trends in March 2016, the PVCellTech conference in Kuala Lumpur, Malaysia, hosted by *Photovoltaics International*'s publisher, Solar Media, provided a fascinating insight into what can be expected during the second half of 2016. Leading the drive to higher cell efficiencies and panel powers are efforts to increase the production of passivated emitter rear contact, or PERC, cells. This new trend can be seen to be driving the internal roadmaps of all silicon cell manufacturers, in addition to competing n-type and thin-film providers.

After several years of underinvestment in cell production technologies, there has been increased focus over the past 12-18 months, with panel powers for the industry-standard 60-cell p-type modules now reaching and exceeding 260W in mass production. While much of the growth from 240W to 260W-plus has come from improvements in wafer quality, changing process flows for advanced cell production looks set to form the basis for shifting power levels for this module type to 270-290W over the next few years.

The recent PVCellTech conference during March 2016 in Kuala Lumpur saw almost every leading c-Si cell producer talk about internal roadmaps, challenges confronting manufacturing today and opportunities to move cell efficiencies above the 20% level in mass production. The conference revealed however a broader mix of technologies, each seeking to differentiate with different combinations of cost and efficiency. This included n-type variants and p-type mono approaches, with much of the p-type mono and multi efforts currently focused on increasing the percentage of in-house cell capacity converted to PERC.

These new investments at the cell stage are also pivotal to wafer supply to the industry, incorporating silicon consumption levels and ingot growth methods, and also encompass the plans of thin-film producers, especially First Solar, to react again to progress made by competing c-Si market offerings.

This article summarizes the key themes that emerged from the PVCellTech event in Malaysia, reviews what the 2016 cell production landscape is expected to look like by year-end and compares the technology roadmap recently announced by First Solar just after the PVCellTech event was concluded.

The findings reveal the emergence of a highly vibrant sector today, where technology innovation is set to be elevated in importance as a route for companies to differentiate product offerings and their roles in driving panel power levels to increasingly higher levels in the next two to three years.

Credit: Hanwha Q CELLS

Technology innovation is set to grow in importance as PV manufacturers seek ways to differentiate themselves from competitors.

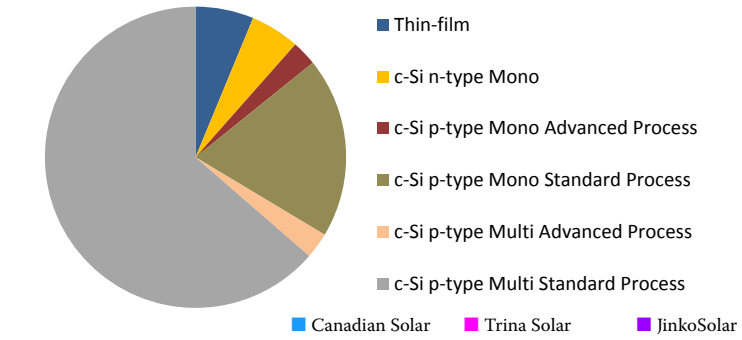

Figure 1: Approximately two-thirds of solar PV capacity produced during 2015 was based on standard p-type multi cells, reflecting the preference of cell producers in China, Taiwan and Southeast Asia. Advanced p-type offerings in 2015 highlight the initial impact of adding rear passivation layers also.

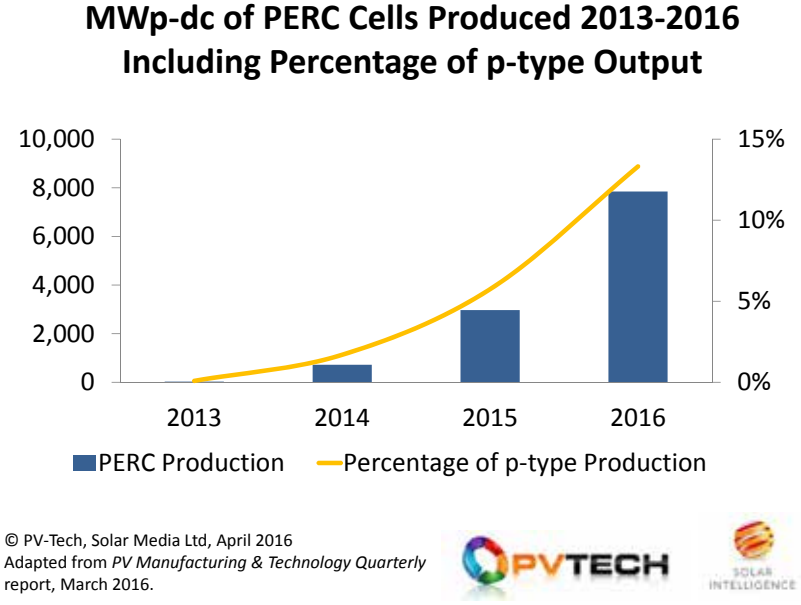

Figure 2: PERC production has seen strong growth from 2015, with the biggest impact set to occur during 2016, with PERC-type cells accounting for more than 10% of all p-type c-Si output by MW volume.

Solar PV manufacturing technology at the end of 2015

Solar manufacturing in 2015 was still adjusting to the changes in end-market demand that had occurred following the days of European end-market dominance, with the requirements for panels shipping to countries such as Japan, China, India, the US and a post-trade-constrained European market being somewhat different.

Indeed, the impact of these changes has driven so many changes through the upstream sector, driving decisions to add certain levels of new capacities within China and across Southeast Asia. In addition, the choice of technologies used in new factories within and outside China has also created a somewhat artificial segmentation within the industry today, and has almost been the most important factor in how the PV technology roadmap evolved until the end of 2015.

Central to this has been the addition of new cell capacity outside China and Taiwan, in order to circumvent import costs associated with serving end-market module shipments to Europe and the US. In contrast, increased end-market demand from countries such as China and India has created a captive market for China-based cell and module capacity, where average selling prices are amongst the lowest seen in the industry today.

Figure 1 shows the breakdown of cell production during 2015, with thin-film included here also to allow capturing the underlying technologies used for all modules shipped to the end market for the year.

Increasing PERC production in 2016

There was little doubt during 2015 that the main drive for p-type cell manufacturers was to overcome the challenges in implementing PERC into mass production, and the conclusions from the event captured this clearly. While much of the effort from industry leaders such as Hanwha Q CELLS, REC Solar and SolarWorld had been as a result of in-house R&D that extended back many years, the other segment of c-Si manufacturing that had been seeking to overcome manufacturing challenges can be seen to come from Taiwan, and in particular from Sunrise Global Solar Energy and Gintech. Understanding how to eliminate light-induced degradation was a key topic each producer highlighted as critical to making PERC work in a manufacturing environment.

As with every new technology being introduced into solar cell manufacturing, there are always claims and counter-claims, and during 2014 and 2015 there was no shortage of announcements in the press related to company plans for PERC technology implementation. In fact, there was barely a company that did not claim to be either working on PERC or showing a PERC-based module at a trade exhibition globally.

However, the litmus test remains what is genuinely being produced in mass production by cell makers, and this can only be tracked bottom-up through detailed analysis across the different cell producers that supply the industry today. This removes the hype, prevents spurious data being communicated and ultimately frames the level to which PERC has been taking market share away from standard p-type cell production (both mono and multi).

Figure 2 reveals the true extent of

PERC production, and shows as a percentage of p-type cell production only. While early adopters were able to ship initial volumes to the market in 2013 and 2014, it was 2015 that represented the first real growth phase for the technology. Success during initial production lines at a small subset of cell producers then had the effect of pulling in competitors to the field, but also resulted in the early movers committing to upgrading more existing and new lines to be PERC-capable.

Indeed, these trends were clear to see when looking at equipment orders placed on key tool suppliers such as Meyer Burger (the dominant PECVD suppliers) and laser tool suppliers Innolas and 3D-Micromac. Much of the new order intake for these companies was based on shipment schedules weighted to the second half of 2015 and the first half of 2016. In fact, the level of new order intake, coupled with the relatively few equipment providers during 2015, had led to a backlog of tool orders and push-outs that will ultimately see much of the 2015 order activity being spread across most of 2016.

Renewed focus on n-type production

The other key finding from PVCellTech was an uptick in the aspirations of new cell producers and the equipment supply chain to promote n-type cell manufacturing. Here, the conclusions are less compelling however, with the 2016 production landscape not directly suggesting any immediate change to the status quo in the industry.

In some respects, there still appears to be a great deal of faith put on the 'International Technology Roadmap for Photovoltaic' (ITRPV) report predictions for n-type market share going forward, in particular for heterojunction-based variants. This is not new for the solar industry, as there has always been emphasis placed on reaching the highest efficiencies with the most exotic cell architecture, often underestimating the barriers to entry or competitive companies' roadmaps.

Based purely on what is being made today, and what will likely be produced between now and the end of 2016, it would be relatively easy to dismiss the aspirations of companies such as Silevo (part of SolarCity), TetraSun (part of First Solar) or various new entrants that have chosen to bypass p-type manufacturing altogether. However, the reality is that in 2016, n-type supply to the end market will remain dominated by SunPower, Panasonic and LG Electronics, with the original plans of Mission Solar Energy having been downsized since original goals were set before mass production had been achieved.

More than once during the two-day Malaysia event in March, questions were raised as to whether the new efficiency roadmaps for p-type mono and multi cell production, that were all leading to mass production activity north of 20%, were in effect making some of the n-type approaches almost obsolete in the industry today.

If this is the case, then n-type market-share gains would come purely from the success of advanced cell variants that only SunPower and Panasonic have managed to move from R&D to mass production until now. In this respect, the big difference today with the new n-type advocates and these two companies would appear to be the role that equipment suppliers are playing, in particular with PECVD and PVD tools.

In the past, SunPower and Panasonic were instrumental in creating equipment and supply-chain specifications that have until now remained the critical IP that allows them to operate their cell architectures at high volume and low cost. Whether the new cell entrants, operating somewhat differently with equipment suppliers, can replicate this formula is likely to be one of the key factors that will determine whether n-type end-market contributions will have a greater number of suppliers in 2017 and beyond.

Secondary impact on thin-film roadmaps

Aside from the impact that PERC introductions to p-type cell production have had on the plans for n-type cell producers, there is also the cumulative effect on thin-film manufacturing in general. However, in contrast to the roadmaps from before 2010 that considered all types of thin-film types to be a direct threat to c-Si, any discussion of thin-film largely falls on one company: First Solar.

While it is true that just two companies dominate thin-film production today (First Solar and Solar Frontier), only First Solar is providing indications of adding new capacity and technology over the next few years. Coupled with its extensive R&D spend and allocations to manufacturing capex each year, the case for isolating First Solar as the main thin-film threat to c-Si today is more compelling.

While PVCellTech focused on c-Si cell manufacturing, it was equally relevant and revealing to then learn about First Solar's PV technology roadmap plans during April 2016. In this respect, as discussed below, First Solar's plans are every bit as relevant as the prospects for n-type capacity increases.

In the past few years, First Solar has been increasing average fleet efficiency levels (at the module level) at incremental rates that are above those seen across the whole c-Si community. Coupled with bringing back mothballed production lines, First Solar is nonetheless moving towards a ceiling on capacity by the end of 2017 at the 4GW mark. To move beyond this either requires additional production lines using the same panel size used today (0.6x1.2m), and the related facilities/infrastructure to house the new production lines.

Instead of committing to this route, First Solar is now proposing to introduce new capacity based on a 3X jump in panel size, first through back-end assembly of the smaller panel size to form a thin-film equivalent of the 72-cell module size, and then by having front-end full large-area deposition on glass panels measuring 1.2x1.8m.

While far from set in stone as a roadmap deliverable, and potentially subject to changes in production plans at First Solar, it nonetheless is a significant move from a technology standpoint, and every bit as ambitious as the new GW entrants to heterojunction cell capacity ramping.

In both cases however, the driver can be seen to be p-type c-Si and in particular the efficiency gains on multi wafers/cells that were simply never considered possible a decade ago in the industry. Common to all though is a new focus on manufacturing and technology that, regardless of the winners and losers, is certain to reshape and redefine solar PV manufacturing in 2017, and will likely again be the source of stimulating debate by the time we reach March next year and PVCellTech 2017.

About the Author

Dr. Finlay Colville is Head of Market Intelligence at Solar Media, the parent company that also publishes PV Tech and Photovoltaics International. Prior to this, Dr. Colville was Head of Solar at NPD Solarbuzz between 2010 and 2014. As the leading market analyst tracking PV manufacturing, technology and equipment spending trends, Dr. Colville has been active in the solar industry for more than a decade. Prior to NPD Solarbuzz, he held various senior sales and marketing positions at leading capital equipment supplier, Coherent Inc. He holds a BSc. in Physics from the University of Glasgow, and a PhD in Nonlinear Photonics from the University of St. Andrews, Scotland.