Cell technology trends impacting module supply in 2017

Finlay Colville, Head of Market Research, Solar Media

ABSTRACT
The rebound in solar cell capital expenditures during 2015 and 2016 has resulted in strong capacity additions and upgrade spending that is set to redefine the technology landscape in 2017 and beyond. Within this however is a broad range of drivers, impacting the mix of n-type and p-type cells produced, in addition to the various strategies employed to increase cell efficiencies while reducing overall blended manufacturing costs. Coupled with the various module types being selected within the key global end markets, and the balance between effective capacity and market demand, 2017 is forecast to see a range of approaches adopted by cell producers, with technology differentiation becoming increasingly important across the entire industry.

Historically, when the solar industry has gone through previous overcapacity cycles, the outcome has been characterized by surviving cell manufacturers prioritizing cost reduction as the key metric to focus on, in order to restore manufacturing gross margins to acceptable mid-teen percentage levels. At the same time, process optimization and yield enhancements have also been targeted, often being the driving force behind efficiency improvements.

This was seen last in the solar industry back in 2011-2012, while at the same time some of the more speculative challenging technology approaches (largely coming from thin-film variants) were removed from the manufacturing landscape going forward.

During this previous overcapacity phase in the industry, few companies (with the exception of SunPower and First Solar) elected to perform process flow changes that would see stepwise cell improvements.

As we move into the final quarter of 2016, once again we are confronted by a cell and module overcapacity situation. However, in contrast to 2011-2012, the industry is already in the midst of process flow changes to both p-type mono and multi technologies. This is creating new benchmarks for cell producers to reach in order to stay competitive and will ensure that 2017 sees continued investments into process flow changes, despite any significant levels of new cell capacity being required to be brought online.

This article reviews the main cell technologies that are likely to become industry-standard by the end of 2017, highlighting the leading companies that are pivotal to the competing upgrade paths coming to fruition during the year. In addition, a short-term roadmap is presented that reflects the dominant mainstream supply of p-type mono and multi cells to the market.

The basis of the forecasts comes directly from a three-month research phase that overlapped with a series of interviews with the technical advisory board for the forthcoming PV CellTech conference in Penang, Malaysia on 14-15 March 2017. The findings are supplemented here by data and graphics derived from the October 2016 release of the PV Technology & Manufacturing Quarterly report from Solar Media, publisher of *Photovoltaics International*.

The interplay between effective capacity, capex and marketdemand

Underpinning the need for new cell capacity is primarily the balance between effective cell capacity and end-market demand. Adding to this are the various aspirations of component manufacturers to increase market share, and the impact of trade-barrier restrictions (mainly into the US market) on manufacturing cells and modules in China and Taiwan.

The overcapacity phase of the industry during 2011-2012 was largely corrected during 2013 and 2014, with limited capex being allocated by cell manufacturers. This saw the effective-capacity/market-demand balance restored by the end of 2015, with the growth in demand being the main driver for this change. In 2015, effective cell capacity was approximately 15% above end-market demand, representing a relatively healthy situation.

However, during 2015 and 2016, there has been a significant uptick in cell capex that has caused the overcapacity factor to rebound and will approach 25% during 2017. This dynamic is largely behind the current cell overcapacity situation that is impacting the industry today and is likely to continue to at least the end of 2017. This is illustrated clearly in Figure 1.

Competition within mainstream p-type cell manufacturing

In contrast to other solar technology roadmaps that are offered to forecast

Wafer cost reduction looks set to become an increasingly important driver for manufacturers going into 2017.

Credit: Solar World

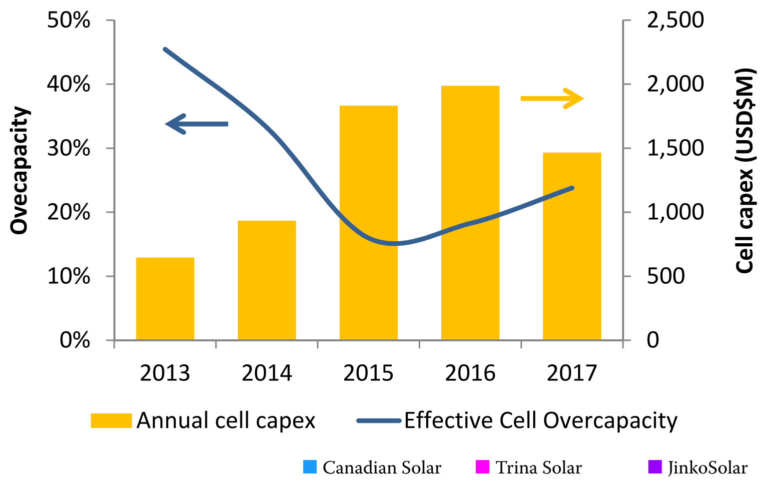

Figure 1. Effective cell overcapacity declined from over 40% in 2013 to a more acceptable level of approximately 15% in 2015, but will rebound to 25% in 2017 following the cell capex uptick in 2015 and 2016 that was above end-market growth requirements. Source: Solar Intelligence, Solar Media.

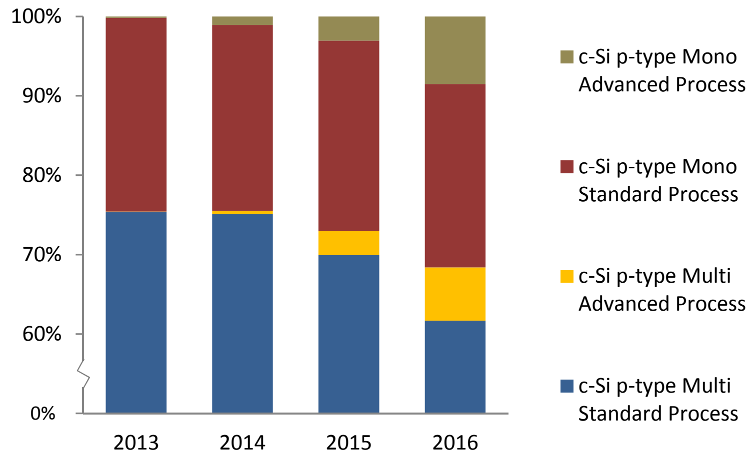

Figure 2. During 2015 and 2016, p-type mono has seen modest market-share gains, compared to p-type multi that was contributing about 75% of p-type market demand in 2013. Each of p-type mono and multi have seen process flow changes to advanced process flow options, with PERC the leading candidate until now. Source: Solar Intelligence, Solar Media.

trends in manufacturing, we use a different means of isolating the key drivers today. This is done by effectively removing all thin-film approaches, in addition to n-type cell manufacturing.

While thin-film and n-type manufacturing are, of course, fundamentally different in nature, the strategies adopted by the various companies producing these type of modules can be grouped together, and isolated from the dominant (90%-plus) market share that p-type cell production commands in the industry.

The companies in question, comprising thin-film and n-type production, are mainly First Solar, Solar Frontier, SunPower, Panasonic and LG Electronics. Today, these companies have very different strategies to all other module suppliers that are focused on p-type silicon.

Therefore, we can largely focus on the legacy mono versus multi share trends for p-type and how each of these variants is undergoing productivity enhancements to increase cell efficiency levels. Figure 2 shows the market share trends of mono and multi cell production, specific to p-type supply during 2013 to 2016.

During 2016, we can see several drivers behind the mono versus multi changes for p-type cell production. Before looking at the advanced cell gains, the overall shift to mono can largely be traced back to the aggressive upstream ingot/wafer capacity expansion plans from LONGi Silicon.

Focused specifically on mono wafer supply, and now incorporating its subsidiary LERRI Solar for cell and module production, LONGi has driven the supply of mono wafers more than any other mono wafer supplier to the industry until now. Benefiting also from low-cost manufacturing, LONGi has now evolved into the leading supplier of mono wafers to the solar industry, growing its share of p-type mono wafers from approximately 10% in 2013 to more than 30% during 2016, with upside to reahch almost 40% during 2017 if expansions continue next year as planned. This is shown in Figure 3.

The timing of LONGi's expansion plans is also significant. Currently, the leading end market for solar demand is China, and this country has established a dedicated demand portion (under the banner of Front Runner) that demands high-efficiency module supply. This has created an uptick in mono module supply, in contrast to p-type multi modules that were dominant in the country during its early growth phase.

Another factor for LONGi's success can be seen with the convergence of mono and multi wafer pricing recently, caused in part by the production excess created by LONGi's ramp, but also reflecting an inevitable pricing equivalence that allows cell makers to decide upon wafer supply (mono versus multi) based largely on pricing alone.

The final driver for increased mono adoption has been coming from the relative ease with which Asian p-type cell manufacturers have been able to upgrade mono cell lines to incorporate passivated emitter rear contact (PERC) based technologies. Coupled with the challenges in upgrading p-type multi lines to PERC, this has ensured that mono has not only caught up with multi this year, but is challenging to gain more market share next year.

What next for p-type multi?

In looking at p-type multi cell production, again we cannot decouple wafer supply from cell production. In fact, the link between ingot-to-cell stages for p-type multi is more important than for p-type mono, based on the requirement of multi wafer quality to be aligned to cell process flow changes.

When viewing the development of p-type multi in this way, it is important to highlight the role of GCL Poly as analogous to that of LONGi for mono wafer supply. GCL Poly was largely responsible for multi retaining market-share levels of 75% back in 2013, and if multi is to see a resurgence it is hard to

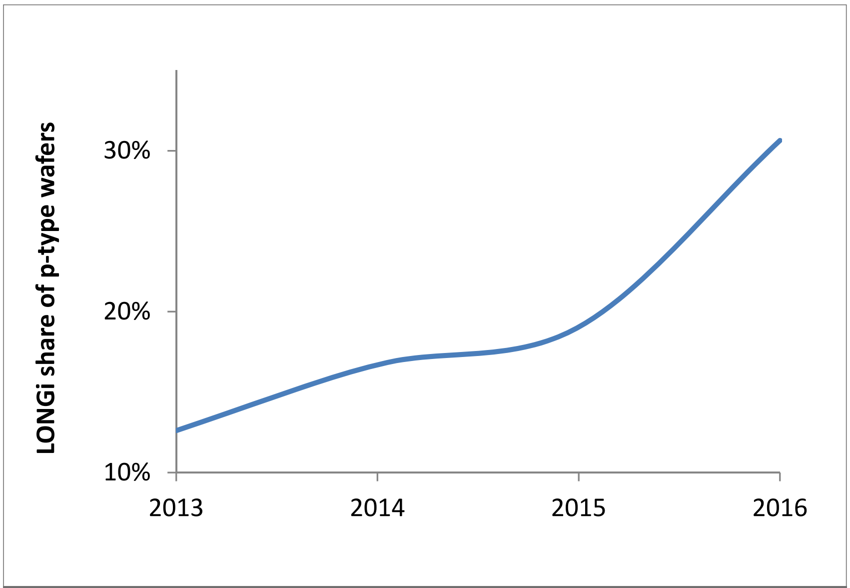

Figure 3. LONGi Silicon has increased its share of p-type mono wafers to more than 30% in 2016, with 2017 likely to grow to almost 40%, following an aggressive and highly-focused strategy to become the leading supplier of mono products to the solar industry. Source: Solar Intelligence, Solar Media.

see how GCL Poly's wafer strategy can be decoupled.

While LONGi has a clear strategy to focus on mono, GCL Poly (and also that of its affiliate GCL Systems Integration for cell and module manufacturing) has been somewhat dabbling in other solar technologies, all the way from polysilicon supply (by virtue of its attempts to move into FBR production) through to cell manufacturing (plans for n-type bifacial, n-type heterojunction, p-type mono PERC ,and p-type multi black silicon).

Indeed, at the ingot/wafering stage, GCL Poly had for some time been presenting an internal roadmap that suggested increased cast-mono and mono pulling adoption, to complement its core strengths in p-type casting and multi wafer supply to the industry. However, in recent weeks, the company appears to have reprioritized p-type multi wafering, with suggestions that large-scale deployment of diamond wire sawing could be implemented.

While such a move by GCL Poly would be significant for p-type wafer supply – and subsequent developments in 2017 at p-type cell production generally – it does still contradict the midstream strategy of GCL Systems Integration. Nonetheless, the drivers here are highly significant, in terms of introducing diamond wire sawing (previously confined to mono wafer slicing) for p-type multi wafering.

The background to this claim can be framed as follows. With PERC being the industry's chosen candidate for p-type efficiency enhancements, and set against a backdrop of Hanwha Q-CELLS and REC Solar having effectively solved the multi-PERC manufacturing challenge, many cell producers in Taiwan and China went through a phase of thinking that multi-PERC would simply follow mono-PERC as the upgrade path for p-type multi cell production.

This roadmap did not come to fruition for p-type multi PERC in Taiwan and China, leaving p-type multi without a clear upgrade path in 2017, and at risk of being left behind in an environment where LONGi was increasing supply of p-type mono wafers at near multi-wafer price equivalence. So what was left for multi cell producers?

The answer to this question may well reside in a dual approach by multi ingot/wafer suppliers and multi cell producers, whereby the cost reductions that are characteristic of moving to diamond wire sawing are implemented for the multi segment. However, this now requires that both wafer suppliers and cell producers are fully aligned in solving the upgrade path, previously held back by the requirement to change front-side texturing of multi cells.

This is where the so-called black silicon cell processing emerges today. Previously, black silicon was a term given to highly complex, largely lab-based, texturing methods that created a black absorber surface on the cells, thereby enabling passivation layer deposition to be optimized in isolation from its current dual role in depositing an anti-reflection coating onto the solar cells.

Now, black silicon is being used as the term that describes an etching process (either dry or reactive ion etching, or metal-assisted chemical etching) that provides the correct front-end step needed when using p-type wafers, sliced using diamond wire saws.

This route would appear to be emerging as the next upgrade path for p-type multi wafering and cell production, with wafer cost reduction being the dominant driver, as opposed to the incremental efficiency changes seen in resulting cell production. However, by focusing on this approach, it also buys p-type multi cell producers time to work out how properly to implement multi-PERC upgrades.

Therefore, in looking at a simplified p-type multi cell roadmap going forward, we may see the remainder of 2016 and the whole of 2017 as a period where diamond wire sawing becomes standard for p-type multi wafers, and cell lines are upgraded at the front-end texturing stage. Then, in 2018, multi-PERC could be reintroduced as the next upgrade step for multi. Combined, these two improvements would help multi to see both strong cost reductions and efficiency gains that now appear to be essential to stop mono supply seeing more market-share gains.

Topics to dominate PV CellTech in March 2017

By the time we get to March 2017, and the second PV CellTech conference in Penang, Malaysia, it will be much clearer what has been achieved by multi wafer/cell production, and also how this is reflected in wafer ASPs and average cell efficiencies using the new front-end texturing tools. Whether the industry manages however to be aligned on multi wafer and cell roadmaps does remain to be seen, with the track record here not particularly impressive.

If multi does rebound in this way, it will largely be done as a result of LONGi's threat in terms of changing the status quo within p-type wafer supply. Either way, LONGi is almost certain to go from strength to strength, becoming a more dominant factor in mono versus multi in the market today than the cell manufacturers that have traditionally been regarded as the key instrument of change when compiling technology roadmaps for future market share trends.

About the Author

Finlay Colville joined Solar Media in June 2015 as head of the new Solar Intelligence activities. Until October 2014, he was vice president and head of solar at NPD Solarbuzz. Widely recognised as a leading authority on the solar PV industry, he has presented at almost every solar conference and event worldwide, and has authored hundreds of technical blogs and articles in the past few years. He holds a BSc in Physics and a PhD in nonlinear photonics.