Module materials overview report 2013

Mark Thirsk, Linx Consulting LLC, Mendon, Massachusetts, USA

ABSTRACT

Module assembly drives as much as a third of the total module cost and can have a significant impact on overall module performance in terms of efficiency and module lifetime. This paper reviews some of the newest moduling material trends, and the outlook for the module market.

Introduction

The economic headwinds over the last four years have created turmoil in the PV industry. Unstable demand, dramatic price reductions, variable subsidy support and a turbulent time for all supply chain participants have resulted from the global recession which began to bite in 2009. As 2013 moves into the second quarter the challenges of the last few years remain very much the same, with only anaemic growth forecast in many regions of the world.

The economic downturn has propelled national and regional governments into austerity, leading to cuts in spending on PV subsidies and renewable energy initiatives; but, despite the economic challenges, the global PV industry has shown continued growth in installations on an ongoing basis. In fact, there has never been a significant contraction in the volume of installed generation capacity to date. Growth in 2012 topped double digits, and because of the continued enthusiasm for financial support in certain countries, growth of capacity installation will continue through 2013. This impressive performance belies the vicious cycle which is occurring throughout the module supply chain, and which is affecting all players in the supply of materials and equipment to the PV moduling industry.

This vicious cycle stems from the global economic conditions. As regional and national governments struggle to manage the fiscal situation, subsidy programmes come under pressure and subsidies are reduced. Reduced subsidies result in lower demand for solar installations, and thus lower demand for modules, inverters and other critical components. In an industry that is growing so quickly, scale has been an important part of the strategy of most market leaders. To achieve this scale, capacity additions must be pursued aggressively, and are financed with the expectation of a large market that can absorb the increased production. The resulting overcapacity drives all players to reduce costs, but maintain production in an effort to amortize sunken capital. Inventories grow, driving the entire distribution network to push down pricing to the point of nearly nonexistent profits. The resulting cost pressure within the manufacturing chain is passed to all suppliers, and margins collapse in a race to maintain sales volume.

Many hoped that in 2012 we had reached the sales price bottom and were seeing some return to pricing stability for modules. While there is some evidence that module price declines are slowing, it is extremely unlikely that there will be significant price appreciation through 2013. Economic conditions throughout the world remain challenging, and even in regions where growth appears healthy, such as China, economic warning signs are appearing.

Against this troubling background the solar module market has effectively shaken out to three significant module technologies, accounting for the vast majority of demand. Crystalline silicon modules (both polycrystalline and monocrystalline) dominate the installed volumes, with thin-film cadmium telluride modules meeting most of the remaining demand. The next technology segment is met by CIGS modules from multiple small suppliers. In the rest of this article, these three technologies will be discussed, with a focus on crystalline silicon modules in technology.

Module technology trends

At each step of the production of a crystalline silicon PV module the raw materials dominate the overall production cost. This remains the case in the conversion of finished silicon cells into an assembled module, and materials contribute about 80% of the overall module cost. The materials required can be broken down into a very short list:

- Tab and stringer materials
- Encapsulant or adhesive
- Backsheet
- Front and back glass
- Frames

Modules have maintained a relatively constant design, and most of the changes occurring within module technology are incremental improvements of the performance of individual components. Changes within each technology step, and the materials involved, over the past 12 to 36 months are summarized below.

Tab and stringer materials

As drivers for the reduction of silicon usage continue, tabs and stringers have become the primary conductors for both front and rear sides. By reducing the printed solder bonding area on the cells, and ensuring that the bonding is aligned, the amount of silver paste used for front and rear busbars can be dramatically reduced. While little has changed in the technology for standard stringers, the availability of copper-clad backsheets for use in back-side contact architectures is enabling this technology to be developed, although it features in only a small percentage of module designs.

Credit: aleo solar

The drive to reduce silicon usage has increased the importance of tabs and stringers as primary conductors.

Encapsulant

There have been changes in basic polymers used for encapsulants as well as improvements in the most commonly used EVA-based encapsulants. Suppliers are offering polyvinyl butyral (PVB), olefin and silicone-based encapsulant technology as high-performance alternatives to EVA. Meanwhile, EVA encapsulants with ultrafast cure times, high dimensional stability, and high transmission and sodium ion barrier properties have all been developed to improve more traditional module designs.

Credit: Solar-Fabrik

Basic encapsulant polymers have been changed and EVA-based encapsulants improved.

For many thin-film module designs, the thermoplastic encapsulant has been replaced by EVA. Edge-sealing technologies mitigate the moisture sensitivity of the thin-film absorber. This design has replaced the glass/glass designs used in many CIGS modules, and is favoured by Frontier Solar, the largest CIGS supplier. However, the First Solar CdTe module design has remained with strengthened front glass and tempered back glass encapsulated with EVA, but still using an edge seal.

Backsheet

Similarly to encapsulants, there have been incremental improvements in backsheet performance, as well as the development of replacement materials for components of laminated backsheets. Supply shortages of polyvinyl fluoride (PVF) in the last two to three years have led to the adoption of other fluoropolymers such as polyvinylidene fluoride (PVDF) or solution-coated fluoropolymer protective layers. Among other factors, cost reduction has helped to drive a reduction in the number of fluoropolymer layers in backsheet laminates, with products becoming available with a single fluoropolymer on the outside, or even laminated polyethylene terephthalate (PET) backsheets with each layer offering different functionalities. These PET-only backsheets have been aided by the development of additives to the PET to improve weathering and reduce UV degradation.

Credit: Madico

Modifications such as replacement materials for laminated backsheets have driven gradual performance improvements.

Improvements in heat radiation, internal reflectivity or transparency for bifacial modules have also been achieved, allowing increased module efficiency.

Front glass

Traditional moulded glasses account for significant cost and weight within the module design. Some progress has been made in reducing glass thickness in order to decrease both cost and module weight. To reduce glass defects some module makers, although only a minority, have migrated to float glass to achieve higher efficiencies.

Notably, for very high efficiency modules, the front glass is increasingly being coated with anti-reflective materials, which can achieve up to a 4% improvement in light transmission. Although anti-reflective coatings have been expensive in the past, cost reduction has brought the price down to a more economically favourable level.

Frames

An increasing number of glass and backsheet modules are offered as frameless options. Concerns about moisture ingress remain: some manufacturers have used polyisobutylene (PIB) sealants, while others maintain that standard encapsulants are acceptable. Many frameless modules rely on a front and rear glass design for better protection of the cells; however, an increasing number of frameless module designs are being promoted, with a significant number of designs using front and back glass.

Credit: ET Solar

A growing number of modules are now offered as frameless options.

Another major influence in module manufacturing is the advent of much-improved testing. Luminescence imaging of assembled modules has become accurate enough to diagnose systematic defects and has resulted in a vast improvement in module quality. As the old adage goes, "You can't fix what you can't see." Many production faults, from microcracks in cells to hot spots and connection faults, can be visualized, and these can be addressed in production.

Manufacturing concerns within the moduling supply chain

Turbulent business conditions in 2011 and 2012 have resulted in significant numbers of players at all levels of the supply chain moving into loss-making territory, and many into bankruptcy. The surviving supply chain participants have gone through many rounds of cost reduction, and are still challenged to realize value for differentiated products.

Some of the trends for cost reduction are common to many players. These approaches include reducing overheads, increasing productivity, adopting best-in-class manufacturing practices, debottlenecking existing manufacturing, optimizing sales and distribution, and shutting down out-of-date or inefficient manufacturing locations. All of these benefit the industry in the long run by setting low-cost benchmarks for the supply chain. Consolidation of a number of suppliers has resulted in a smaller number of overall players in many markets.

Some of the material-specific improvements include moving from the supply of polymer films in the form of rolls, to precut sheets, which enables module manufacturers to save scrap material and increase productivity; the polymer film supplier is often in a better position to recycle scrap material than the module maker, thus reducing cost per module. Fast-curing EVA encapsulants and thermoplastic encapsulants offer cost savings to module makers through improvements in productivity and reduced investment in laminating systems. Although attractive under normal conditions, these approaches are less effective at present, since overcapacity within the moduling industry reduces the need for productivity improvements.

Consolidation of suppliers delivers the benefit of increased purchasing power within a smaller number of surviving suppliers, offering attractive pricing for volume purchases of raw materials. This reduces raw material cost volatility, but cannot eliminate it. Many of the raw materials for moduling, such as EVA and PVF, suffer from external market forces, which leads to high resin cost volatility, just as metal prices have seen price spikes in recent years. At times when margins are narrow, increases in raw material costs are passed on to module makers by suppliers. Several suppliers have reported favourable drops in raw material costs in 2012, which have helped them deliver price reductions, although in a commodity market it is likely that these trends may reverse.

Perhaps the biggest concern, and the most visible structural change within the industry, has been the shift of the supply chain to China. The reduction of supply base capability in Europe, and its migration to China, has been responsible for significant cost reductions, as lower capital and labour costs facilitate lower prices. While this migration of the supply base to China was regarded with suspicion by many module purchasers, Tier 1 module makers proved that they could deliver a reliable supply of high-quality modules, often incorporating brand name materials in module construction that are well regarded by purchasers. Of increasing concern is the fact that as prices have continued to fall, the necessary cuts in cost have been achieved by the substitution or dilution of high-quality materials with lower-cost, lower-quality replacements. This trend has resulted in reports of reduced module quality, which is evidenced by the trend of banks and installers in global markets to increase testing of incoming module construction techniques and materials. Increasing failure rates have been seen by multiple installation companies when substandard materials, which pass standard certification but not rigorous real-world conditions, are found in modules. It is expected that Tier 1 and Tier 2 module suppliers will see it is beneficial for them to move to high-quality materials in order to maintain their brand reputation and optimize the cost of quality; struggling module suppliers, however, may not be able to.

Other structural influences on cost

As margins have narrowed, and the market is constrained by weak demand, technology improvements have been adopted to add value and differentiate products. Even though there has been a significant increase in the pace of innovation within both cell and module manufacturing, decision times for implementation and qualification can still take months or years. This presents a significant challenge for material suppliers in delivering performance improvements while realizing a return on investment for the improvements delivered. Adding to this challenge, moduling companies do not have deep enough pockets to fund the qualification of many performance-enhancing technologies, and have sometimes requested that suppliers aid in paying for the qualification and certification of improved products, pushing the cost load into the supply chain.

Another effect of pricing close to cash cost is that the squeeze on innovation results in a slowing of improvements to materials and manufacturing processes. A characteristic of the solar industry used to be that innovation was spread throughout the supply chain, and novel processes were delivered by materials suppliers, equipment makers or research consortia as well as module makers themselves. As margins have tightened, this engine for improvement has begun to stall, and development budgets will remain hard to find for the foreseeable future. Related to this trend is the challenge of capacity reinvestment. Although many manufacturers recognize that overcapacity and oversupply exist, ROI targets force them to continue production despite weak demand. Products manufactured under these conditions often do not meet company reinvestment thresholds, and as end markets grow, suppliers are unwilling to make the substantial capacity investments to deliver needed products at market costs. Even with an expanded global supply base, this will become a concern for the industry as key suppliers delay capacity expansions necessary for delivering scale economies in the future.

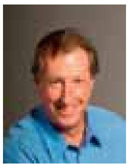
Conclusions

The continuing global recession has taken its toll on the PV industry, although with a broadening global customer base, and more countries and states implementing subsidy programmes, growth has continued. Unit growth is expected to continue in the short term.

The old adage that power (and power density) is king remains true within the solar industry. Challenging times have been met by the solar module manufacturers with a readiness to adopt and implement improved technologies throughout the supply chain, and especially in moduling. This has facilitated the adoption of many new technologies that have gone some of the way in delivering cost reductions needed to compete in these tough times, and locked in improved practices and technologies that in turn lock in these lower costs.

Unfortunately, a compromise in material quality is endangering the ability of both suppliers and installers to achieve a win-win in their projects. Low-quality panels will endanger the profitability of either the supplier or the buyer in the long run, until it is realized that money can be made by all parties with high-quality products.

About the Author



Mark Thirsk is a managing partner and co-founder of Linx Consulting, which provides market-defining analysis and strategic insights across major markets in electronic materials. He has over 25 years' experience in economic and business forecasting, strategic planning, technical marketing, product management and M&A, spanning many segments and processes in electronic materials. Mark has served on the SEMI Chemicals and Gases Manufacturers Group (CGMG) since 1999, acting as chairman between 2001 and 2003. He holds a B.Sc. (Hons.) in metallurgy and materials science from Birmingham University and an MBA from The Open Business School, and has authored multiple publications in both academic and trade publications, as well as contributing to several patents.

Enquiries

Mark Thirsk
Managing Partner
Linx Consulting LLC
P.O. Box 384
Mendon, MA 01756-0384
USA

Tel: +1 617 273 8837
Email: mthirsk@linx-consulting.com
Website: www.linx-consulting.com