

# Forecast for thin-film PV equipment market calls for sustainable growth

John West, VLSI Research, Bedford, UK

This paper first appeared in the eighth print edition of *Photovoltaics International* journal.

## ABSTRACT

The demand for equipment used to manufacture solar photovoltaic solar cells and modules has grown at an explosive rate over the past five years, and the fastest-growing segment has been for systems used to manufacture thin-film cells and modules. In 2009, demand for this type of equipment reached US\$1.9 billion, up from US\$0.1 billion in 2004, representing an astonishing 80% compound annual growth rate over the period. However, as with the rest of the industry, 2009 saw sales flattened and the business model change from one of rapid growth to that of sustainability. The result of this transition has been some consolidation, with several major equipment vendors strengthening their position through acquisitions. The outlook for 2010 calls for sales of thin-film production equipment to recover and continue growing at a compound annual growth rate of around 15% over the next five years (see Fig. 1).

Thin-film PV manufacturing can be broken down into two major sectors: silicon thin film on glass and non-silicon thin film on glass. Each of these segments has evolved very differently, and two distinct market landscapes have emerged.

## Silicon thin film on glass

The key process technologies for producing Si TF-on-glass solar cells and modules are directly derived from semiconductor and flat-panel-display manufacturing, so it is not surprising that the equipment market is dominated by vendors with strong positions in these industries. Indeed, tool suppliers were quick to identify the opportunity to expand into the solar market and did most of the development work in providing manufacturing solutions. The outcome of these efforts resulted in the equipment manufacturers possessing much of the process technology for Si TF, so it was only natural for them to provide complete manufacturing packages. The overwhelming majority of the market for Si TF equipment is supplied as part of a turnkey solution, and this indicates just how much process technology is held by the tool companies.

The three main players in the turnkey space are Applied Materials, Oerlikon Solar, and Ulvac. Since these companies have their origins in vacuum-based thin-film deposition, they have had to buy companies or partner with others to offer a complete production line. Because of this factor, only around half the value of the equipment in these turnkey systems is provided by the supplier of the complete line, while the remainder is provided by third-party equipment manufacturers.

In addition, because the recognition of revenue on these turnkey lines depends on reaching predetermined targets, there can be a long time-lag between shipping tools and getting paid for those tools – which makes it a very difficult market to measure.

# GUARANTEED

## ELEMENTS

CADMIUM  
COPPER  
GALLIUM  
INDIUM  
SELENIUM  
TELLURIUM

## PRODUCTS

ALLOYS  
CHEMICALS  
FABRICATIONS  
METALS  
RECLAIM  
TARGETS



California USA  
Lubeck Germany  
New York USA  
Wellingborough UK  
+1 408 215 6600  
atlumin.com

However, in 2009, new orders for Si TF manufacturing equipment reached US\$900 million, but revenues received exceeded US\$1.5 billion as companies worked through their backlog from the previous year. Looking at this from the perspective of the turnkey market, new orders during the year were only US\$300 million while revenues recognized on turnkey lines were around US\$1.4 billion. It is also worth noting that although revenues for silicon TF turnkey lines were up 50% in 2009, orders fell by 75%, making it a truly unusual year.

The evolution of this market as a mainly turnkey business raises questions about the long-term development of the sector. Successful businesses are typically those that are able to differentiate their product, raise barriers to entry, and lower costs. Si TF cell/module manufacturers that have established their manufacturing capability on the back of turnkey suppliers fail to meet any of these criteria, so the question is, why would they choose this option? The answer is simple: because at the time they made the decision it did not matter, since the PV market was growing rapidly and the most urgent needs were to invest money quickly and get into production as soon as possible.

As the market starts to show signs of stability, big questions about this business model have to be addressed: how do two different companies with the same turnkey solutions compete against each other, and how do groups of companies using the same tool set and process technology compete against companies using rival turnkey solutions?

So far it is not clear how two different companies running the same turnkey lines can compete against each other, since both companies are locked into the same equipment vendor's tool set and process technology. Over time, this issue may be resolved as the Si TFPV manufacturers develop their own process technology, but the most pressing problem appears to be how to compete against rival turnkey solutions and alternative technologies.

### Non-silicon thin film on glass (CdTe, CIGS)

In contrast to the Si TF-on-glass equipment market, most of the process technology in the CdTe and CIGS thin-film PV sectors remains in the hands of the cell and module manufacturers, giving the equipment market a very different structure. In particular, manufacturers have their own processes so they have been instrumental in developing their own process equipment. Many have the production tools made to their own specifications, and equipment vendors are simply "building to print." This arrangement results in a more fragmented equipment market and, until recently, turnkey solutions from equipment vendors have not been available.

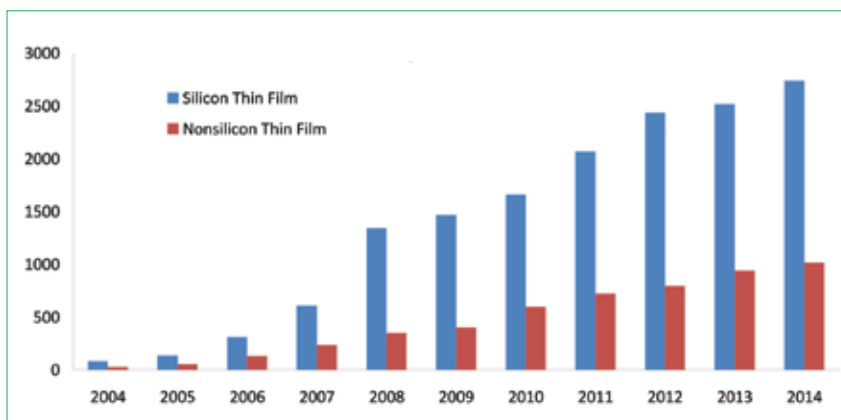


Figure 1. Historical and forecasted sales of thin-film photovoltaic production equipment, 2004-2014.

The industry is dominated by one cell/module manufacturer, First Solar. This company has perfected the CdTe manufacturing process, and it now accounts for around two-thirds of TFPV manufacturing capacity. The implication for the equipment market is that there will continue to be a large captive element until other cell/module manufacturers, which source their equipment from the merchant market, gain traction.

The equipment market is characterized by many small players and a handful of larger players, with Von Ardenne being the main supplier. Sales of equipment for nonsilicon TF manufacturing are difficult to measure because of the captive element provided by machine shops and contract manufacturers, but sales of tools from recognized equipment vendors exceeded US\$400 million in 2009. The market for turnkey solutions finally got under way, with sales of around US\$200 million made during the year. This is significant because the main barrier to entry for this market is technical, and if viable turnkey solutions are available, this could open up the market to other cell/module manufacturers.

### Flexible substrates

While the market for equipment used to process a-Si and CIGS solar cells/modules on flexible substrates is currently very small – around a few tens of millions of dollars in 2009 – it is worth a mention since this technology has the potential to stimulate huge demand in the future. In this sector the equipment suppliers and cell/module manufacturers have been working closely together to solve manufacturing problems and reliability issues inherent in roll-to-roll/flexible web processing, with neither party being dominant. This partnership is clearly working, as commercially viable cells/modules are on the market, and ECD Uni-Solar, the biggest supplier of flexible modules with its triple-junction a-Si laminates, has established itself as one of the leaders in the thin-film sector.

However, to put things into perspective, Uni-Solar is still dwarfed by First Solar. Of the tool suppliers, CIGS systems vendor Veeco looks set to be the main beneficiary, since the market for equipment in 2010 – based on orders already placed – is expected to at least triple.

### Conclusion

There are two very different market structures for silicon TF and non-silicon TF cell/module manufacturing equipment. The defining feature of the Si TF-on-glass equipment market is that it has grown as the result of a push from the tool vendors rather than a pull from cell/module manufacturers. As a consequence of this, the main battle is being fought among the major equipment vendors rather than the cell/module manufacturers. By contrast, the non-silicon TF equipment market is dominated by one cell/module producer. The competition is among cell/module manufacturers and until other cell/module manufacturers can gain market share from First Solar, there will continue to be a large captive element to the equipment market. Overall, because there is greater scope to reduce manufacturing costs and improve cell/module efficiencies, the market for thin-film PV manufacturing equipment is predicted to grow faster than the market as a whole.

### About the Author

**John West** is the managing director of VLSI Research Europe, a firm focused on market research and economic analysis of technical, business, and economic aspects within the photovoltaic, semiconductor, nanotechnology, and related industries. He has been analyzing the PV capital equipment market since 2006.

### Enquiries

Tel: +44 1234 834 662

Email: johnwest@vlsiresearch.com