

Taiwan thin-film manufacturers set for rapid growth

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ABSTRACT

The continued tight supply and high cost of polysilicon, coinciding with the growth in demand for solar energy, has been a key catalyst for the rapid adoption of thin-film technologies in the last two years. Although the technology has been in development for over 15 years, it is only now that thin film has emerged as a viable low cost-per-watt alternative to conventional crystalline silicon cells. Taiwan, a powerhouse in the electronics and microelectronics industries, is also turning its attention to photovoltaics. Playing catch-up is something at which the Taiwanese have proven to be very effective, with a growing emphasis on thin film as a means to become another major centre and net exporter.

First Solar setting the benchmark

After a long (15-year) gestation period, North America-headquartered First Solar has single-handedly thrust thin-film technologies into the spotlight with an impressive manufacturing ramp and full order book that is now worth US\$6.3 billion through 2013 [1]. First Solar announced its third quarter financial results that ended on 27th September 2008, highlighting that production had reached 137MW in the quarter, which was up 20% quarter-on-quarter and an impressive 97% year-on-year [2]. This would mean that First Solar has reached an annualized capacity of 49.3MW per thin-film production line.

Significantly, the cost-per-watt, excluding non-production based expenses now stands at US\$1.01 per watt [3], a 9% reduction quarter-on-quarter and the lowest in the industry, acting as a benchmark for all others. Indeed, an

important point for thin film start-ups is the fact that First Solar turned profitable in 2006 at an annual production rate of 75MW. With cadmium telluride (CdTe) conversion efficiencies of 10% and a roadmap goal of US\$0.70 per watt by 2012, competitors need to take note.

The very public success of First Solar has seen thin-film technologies gain huge interest from potential new entrants as well as from established crystalline solar cell producers such as Q-Cells, Suntech, Sharp and E-Ton to pursue thin-film manufacturing.

Thin films have also proven attractive to late entrants eager to utilise turnkey processes and equipment solutions that significantly reduce the entry risks, while potentially allowing faster megawatt-scale production ramps and a quicker return on investment (ROI).

As Figure 1 shows, Taiwan has attracted a small but growing group of thin-film converts that have established, or are in

the process of establishing, initial volume production manufacturing plants.

Our research relies partially on projections produced earlier in 2008 by ITRI, as well as checks and updates we have undertaken subsequently. In 2006, nominal capacity stood at only 13MW, which consisted primarily of pilot line operations. As some of those projects have since matured, capacity is estimated to have risen to 27.5MW in 2007.

These capacity figures are small; however, when compared to ITRI/*Photovoltaics International's* estimates of crystalline silicon cell capacity having reached 990MW in 2007 (see Figure 2), it seems thin film has a long way to go to challenge silicon solar cells.

As Figure 3 highlights, there is the possibility that thin-film MW capacity will account for over half the capacity in Taiwan in 2010, a possible testament to the faster ramp capability of thin-film technology over conventional Si-cell approaches.

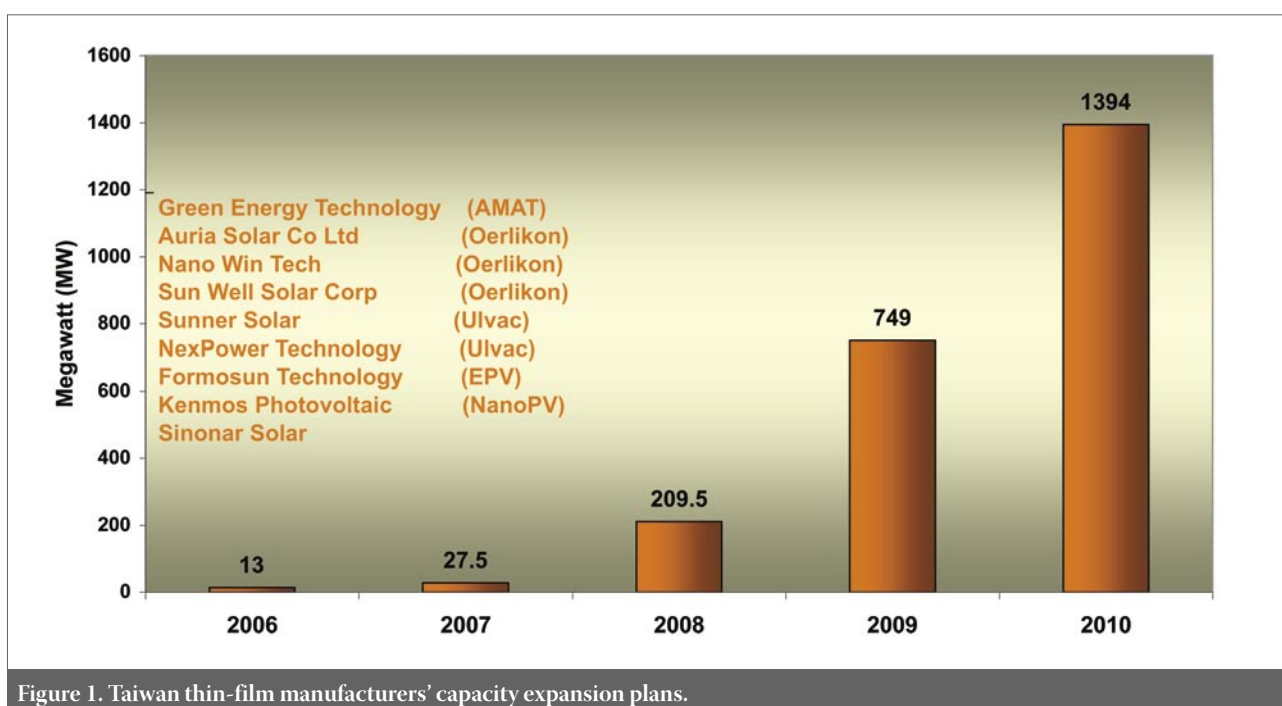


Figure 1. Taiwan thin-film manufacturers' capacity expansion plans.

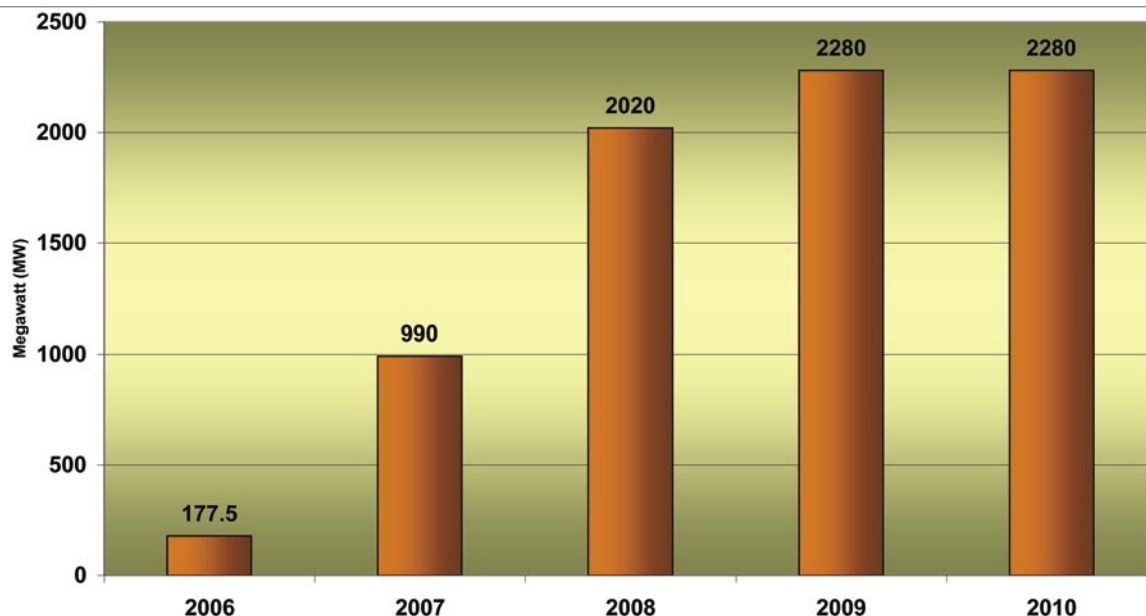


Figure 2. Taiwan c-Si cell producers capacity ramp forecast.

Amorphous thin-film

Interestingly, all of the current thin-film entrants have selected amorphous thin-film technologies from all of the key current suppliers (Applied Materials, Oerlikon Solar and Ulvac). Although development is taking place on cadmium telluride (CdTe) and copper indium gallium (di)selenide- (CIGS) based thin-film solar cells, current production ramps are all a-Si based. The reason for this preference is the less demanding learning curve with a-Si compared to the technical hurdles with which these alternative technologies are associated.

Work is also ongoing to boost conversion efficiencies to the 10% range with twin junction configurations to make them more competitive with CdTe and CIGS technologies. Currently, first generation

a-Si module efficiencies are in the region of 6.5% and Oerlikon Solar's second generation technology a-Si/ μ c-Si tandem structure has 8.7% module efficiency

Company focus

Auria Solar

Founded in October 2007, Auria Solar, a joint venture operation with TON Solar Tech, Lite-On Technology Corp., Hermes-Epitek Corp. and MiTAC-SYNNEX Group (see Figure 3 for financial breakdown) has already announced that its first 30MW thin-film line will include Oerlikon Solar's micromorph tandem technology that utilises amorph and microcrystalline materials to boost conversion efficiency by 50%. Pilot production is expected before the end of 2008.

Auria Solar has had an initial capital injection of approximately US\$43 million

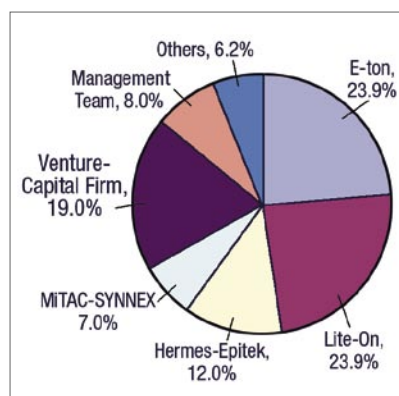


Figure 3. Auria Solar JV – financial breakdown.

and is expected to expand production by 60MW per year, with an ambitious goal of achieving 500MW capacity in 2012.

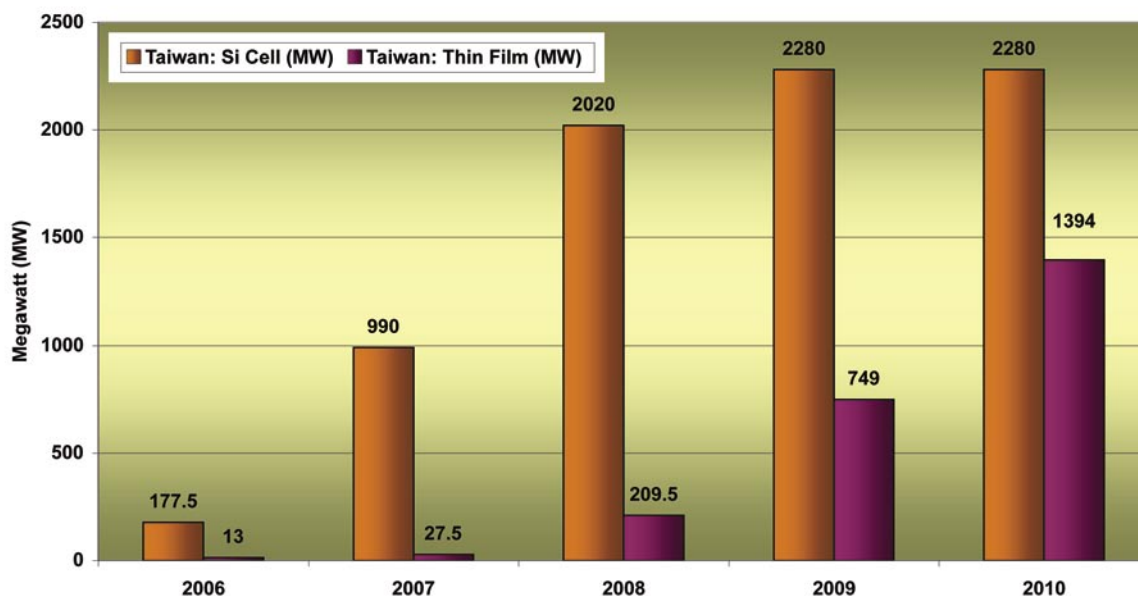


Figure 4. Taiwan PV manufacturers' Si-cell and thin-film capacity expansion plans.

Sun Well

Sun Well Solar Corp. was established in mid-2007 as a subsidiary of CMC Magnetics Corp. The thin-film start-up is using Oerlikon Solar's turnkey technology for an initial single production line with a 40MW capacity. Recently (1st September 2008), Oerlikon Solar stated that Sun Well's first line became operational within nine months. The company was said to have produced 10,000 solar panels in its first month.

Sun Well is planning further line additions with a plan for over 220MW production capacity in 2010. Two additional Oerlikon Solar end-to-end fab lines have been purchased by Sun Well. One 60MW line is for Sun Well's existing site in Taiwan and one 120MW line is for a second facility currently under construction, which will utilize Oerlikon Solar's micromorph tandem technology. Sun Well has future plans to increase capacity to 1GW in 2012, by far the company with the most aggressive capacity plans for the near future.

Sunner Solar

Sunner Solar was founded in June 2007 and is located in the Central Taiwan Science Park. The start-up has employed ULVAC's thin-film technology and has said that it too will incorporate ULVAC's tandem structure that uses a microcrystal (μ c-Si) layer followed by an a-Si process to boost efficiencies. Initial production is a 25MW line (1.1x1.4m modules), which is expected to be operational in 2Q09; however, plans are for Sunner Solar to rapidly migrate its second-phase expansion to microcrystalline tandem technology developed by ULVAC in the second half of 2009. Production capacity is planned to reach 100MW in 2010, while its third-phase capacity increase is planned to hit 200MW before 2012.



Figure 5. NexPower's first thin-film modules.

NexPower Technology

Another customer of ULVAC's thin-film technology and turnkey production lines is NexPower Technology. NexPower Corporation was founded by one of the worldwide leading semiconductor foundry manufacturers, UMC Group, in 2005.

Initial production in 2008 is on a 12.5MW/year line using ULVAC's 1.1x1.4m modules, but plans are in place to ramp lines and capacity to 100MW/year. Like Sunner Solar, NexPower will migrate to microcrystalline tandem technology developed by ULVAC.

ULVAC is providing turnkey production lines that include systems for PECVD, laser scribing, sputtering and sealing as well as technical training and start-up assistance.

Another potential major thin-film producer in Taiwan is Green Energy Technology (GET). GET is a c-Si wafer producer with 200MW annual capacity and uses Applied Materials' SunFab turnkey production technology. GET is expected to have its first 40MW line operational by the end of 2008.

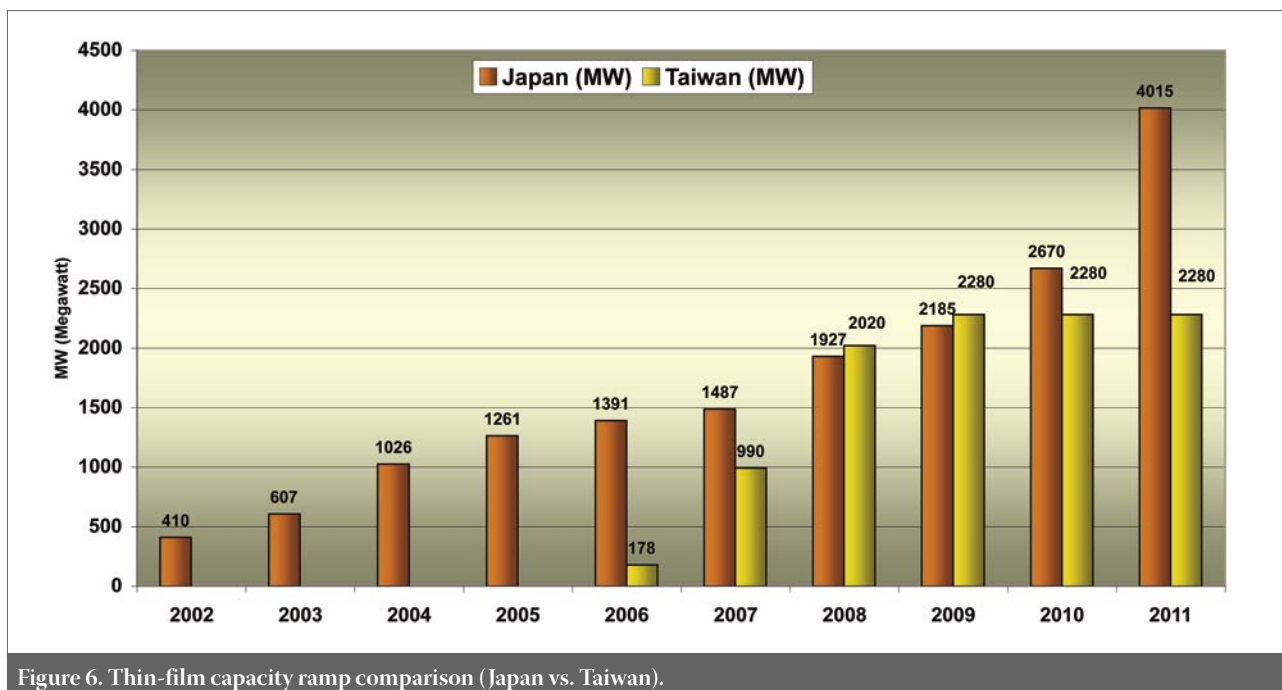
Conclusion

These projections do not account for the likely possibility of the emergence of new thin-film entrants as well as greater capacity ramps from existing start-ups, should initial volume ramps prove highly successful. However, the challenging global economic environment that resulted from a worsening credit crunch could yet impact newcomers' ability to raise funds and for current start-ups to access further capital to expand operations. The prospect for Taiwanese companies to compete with other PV manufacturing regions of the world remains a realistic one (see Figure 6). Efforts for improving conversion efficiencies are underway and experience in low-cost and high-yield electronics manufacturing is a given.

Therefore, 2008 looks like being a year of transition for the photovoltaics industry in Taiwan with both Si-cell and thin-film technologies ramping capacity considerably. Two Oerlikon Solar customers, Sun Well Solar Corp. and Auria Solar Co. Ltd., have stated that installed capacity using a-Si thin-film technology will reach 100MW combined by year-end. With further ramps still expected through 2010, Taiwan is positioning itself as a key hub for PV manufacturing, something it has been successful in doing from semiconductor to PC manufacturing.

References

- [1] Gartner Dataquest Newsletter, Issue 43, 3rd November 2008.
- [2] First Solar, Inc. 3Q08 Financial Statements.
- [3] First Solar, Inc. 3Q08 Financial Statements [note: deducts new facility ramp costs and executive stock-based compensation].



Source: Photovoltaics International