Increasing Thin Film Efficiency: Cost Effective Way to Grid Parity

DR. CHANDAN BANERJEE, MANAGER R&D, HIND HIGH VACUUM COMPANY PVT. LTD.

The challenge is how to increase the efficiency of thin film silicon in a cost effective way. The concept of "micromorph" has a potential role to enhance the efficiency without increasing the production cost considerably.

Among potential new sources of energy the 'Sun' is outstanding. Sunlight is abundant, widely distributed and universally appreciated. Of various energy forms, electricity is highly prized for its general utility. Thus the direct conversion of sunlight to electricity is likely to be a prime method of the future assuming that practical economic means of direct conversion can be developed.

Photovoltaic conversion is a strong candidate for this. It is well known that only 0.1% of the solar energy incident on the earth's surface is enough to meet the present demand of the world, if put into usable form. The growing world demand for electrical energy will be accompanied by a geographical shift since the largest growth rate of this energy expenditure will be situated in the developing nations.

Due to elevated prices of solar grade silicon, the PV industry introduced several different cell technologies based on different materials and thin film technologies. The existing PV yield prediction tools have been created for single and multi-crystalline silicon cells. They are quite accurate and are backed by extensive monitoring. The recently introduced thin-film materials show significant different properties in terms of spectral response, weak light performance, temperature coefficients, flat incidence absorption, and degradation and regeneration effects.

It is seen that the only major disadvantage of the thin solar module is its lower efficiency compared to the crystalline silicon. But there are solutions aimed at improving the absorption of sunlight by the film, which in turn will help to overcome these limitations. Hence the development of low-cost and high efficient thin film solar modules is not very far from the reality and which will have the potential to replace the traditional solar cells that we use now.

The main concern of thin film solar modules is about its breakage and now the technology has been developed to have a non-breakable flexible material as the substrate and encapsulate. Thin film solar modules have a very resilient construction, and they perform well in different weather conditions.

The potential of the thin solar panel film is excellent. The manufacturing volume of the thin film solar materials is growing steadily and fast, and it is expected to continue its rapid growth. Furthermore, thin-film cells are already being actively installed around the world, and this trend is likely to continue.

But still the photovoltaic market has to balance between creating efficient and yet cost effective solar cells. Even though the future is likely to see the thin solar panel film become the market's leader, the traditional crystalline silicon cells are likely to rule the market for at least a few more years, since they are still more efficient than thin film solar materials.

There are mainly three different thin film technologies to date which is available commercially, Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe) and Amorphous Silicon (a-Si). Out of these three technologies, the first two technologies have the clear advantages over a-Si because of its higher conversion efficiencies. But the materials scarcity and the toxicity made them less favorites in long term applications. It is thin film silicon, which is going to rule the market in coming years.

The term thin-film silicon typically refers to silicon-based PV devices other than multicrystalline silicon cells and single-crystalline silicon cells (where the silicon layer is thicker than 200 micrometers). These films have high absorption of light and may require cell thicknesses of only a few micrometers or less.

Now the challenge is how to increase the efficiency of thin film silicon in a cost effective way. The concept of "micromorph" has a potential role to enhance the efficiency without increasing the production cost considerably.

In India the lead in technology development has been taken up by Bangalore based Hind High Vacuum Company Pvt. Ltd (HHV) who has commercialized the amorphous silicon technology based on single junction cells with a stabilized efficiency of better than 6.5%. The production line includes all necessary machineries like PECVD, Sputtering, Laser scribing systems, glass cleaning machine, Sun simulators, Junction Box fixing station etc. The substrate size is 1016 mm x 1016 mm.

HHV's turnkey lines open up a new chapter in the economics of a-Si thin film modules production. With the capital expenditure for setting up a thin film line at around $1.2 / watt , the return on investments are very attractive even at a low capacity of 10 MW , offering scope for very aggressive pricing . This can make a-Si thin film modules highly competitive vis-à-vis other technologies like c-Si and other thin film technologies etc. The benefit will be more pronounced at higher capacities as economies of scale also would add to the attractiveness of the investment.

To enhance the efficiency of thin film

PECVD line for amorphous silicon PV modules.

Inline magnetron sputtering system.


HHV's first 10MW a-Si production line installed at HHV solar campus.

silicon, HHV has adopted two different routes; tandem junction with microcrystalline silicon as bottom cells and then graded band gap cell concepts. Ministry of New and Renewable Energy Sources, Govt. of India has supported HHV in its plan to develop high efficient micro crystalline silicon solar cells and the work is now under progress. The whole challenge to increase the efficiency of the solar cells lies in utilizing the solar spectrum effectively. At HHV we have identified the various areas where we need to improve to enhance the light absorption and the overall efficiency of the cells.

First and foremost is to ensure the proper texturing of the front TCO and to enhance the light trapping into the cell. Another concept is having an intermediate reflector between the amorphous top and microcrystalline bottom cell. This concept permits an increase of the a-Si:H top cell photocurrent due to the difference in the refractive index of the interlayer and the silicon absorbers. Thanks to the high infrared photocurrent potential of the microcrystalline bottom cell a balance of the gained a-Si:H top cell current can principally be achieved by increasing the mc-Si:H cell thickness. Conversely, this interlayer allows a reduction of the a-Si:H top cell thickness while maintaining markedly high photocurrents, accordingly improving the overall stability of the tandem cell.

Another approach has been to use single junction with intrinsic layers of different band gaps, to increase the spectral response over a wide range and which in turn enhance the short circuit current. The cell structure will have wide band gap nanocrystalline silicon layers also.

With these above modifications and improvements a-Si micromorph technology can very easily derive efficiencies greater than 10% and reach towards 12.5%. With the reduced cost of material and lower power costs required for its manufacturing thin film will be able to achieve grid parity at the above efficiency. Capital equipment has always been the challenge of this industry and the high costs of the cap-ex have added to the cost of thin film. However now with the innovation and cost effective manufacturing of world class products at HHV the costs are very attractive and make the effort of thin film technologies in archiving grid parity very realistic.