Solar cell uses front and back

So-called bifacial solar cells can convert incident light into electrical current both on their fronts and backs. They are up to 30 per cent more powerful than conventional monofacial cells that use only their fronts. The hitherto very complicated production of such double-sided solar cells has now been made simpler and less expensive by means of a newly developed doping process.

The researchers in the photovoltaics division at the University of Konstanz were aiming to simplify the production of bifacial solar cells by creating the front and back doping profile of the cells in a single operation. For this purpose they developed a diffusion process based on the APCVD (atmospheric pressure chemical vapour deposition) process. To achieve this chemical vapour deposition at atmospheric pressure they have utilised a new plant system from the Schmid Group. During the diffusion process the different functional layers are applied to wafers. The University of Konstanz and the systems manufacturer have now jointly developed the coating process to series maturity.

The wafers pass through the newly developed APCVD system in five parallel tracks. This achieves a throughput of up to 4,000 wafers per hour. More than 100 of these APCVD continuous furnaces are now in use in solar cell production.

Double-sided doping with the APCVD method

The bifaciality requires an additional p-doping profile that is usually produced by boron diffusion. However, the previously used boron diffusion from the gas phase is a relatively expensive and difficult-to-control process step; it requires a vacuum, high temperatures and a long process time.

The advantage of the APCVD process is that the chemical vapour
deposition does not take place in a vacuum but at atmospheric pressure. This is significantly less energy- and time-consuming than the vacuum process: the process chamber does not have to be evacuated and the reaction gases flow directly into the injection chamber onto the wafer. In addition the APCVD method is an inline process. This means that a virtually unlimited number of wafers can go through the system continuously, whereby several injection heads apply source and cover layers in series. Reaction gases are introduced from separate channels which deposit a homogeneous glass layer on contact with preheated wafers.

In contrast to the previous methods, in which the individual layers were applied step by step under vacuum conditions, the new system works continuously and successively brings the various doping layers onto the wafers in one pass. This doping process makes it possible to simultaneously generate the front and back doping profiles of bifacial solar cells.

**Bifacial solar cell**

With bifacial solar cells, the PV yield can be increased in a resource-saving manner. Compared with monofacial modules, the yields on natural substrates are 8 to 15 per cent higher, and even between 15 and 30 per cent higher relative to white reflectors and with favourable geometry. The most important factors influencing the achievable performance are the substrate's reflectivity (albedo) as well as the height, row spacing, inclination, racked mounting-induced shading and proportion of diffused light.

The solar cells currently dominating the market are based on a p-type silicon substrate with a front-side emitter produced by POCI3 diffusion and an opaque aluminium back surface field (Al-BSF). In the case of bifacial solar cells, local contacting with a finger structure similar to front-side metallisation is used instead of this full-surface area. In addition, the higher quality and non-degrading n-type silicon can be used as the base substrate.

Whereas full-area, back surface field contacting with an Al paste layer prevents standard Al-BSF solar cells from absorbing incident light on their rear sides, the more modern PERC (Passivated Emitter and Rear Contact) solar cells can also be produced in a bifacial variant. These bifacial PERC+ solar cells have an aluminium finger grid on the back instead of full-surface aluminium metallisation. This enables the cells to also absorb scattered light incident on the back and convert it into electricity. Modules with PERC+ solar cells can generate about 5 to 10 per cent more electrical energy than conventional monofacial modules.

**Simpler production of complex solar cells**

The APCVD-based process steps enable future solar cell processes to be produced more cost-effectively. The researchers have further developed the coating system and the process control. This was aimed at increasing the performance of the generated boron-doped layers as well as the throughput, thereby reducing costs. They are currently concentrating on producing doping profiles for bifacial solar cells as cost-effectively and simultaneously as possible. In addition, they want to reduce the recombination and series resistance losses when contacting boron-doped surfaces.

In the MuSkAD follow-up project, the SCHMID Group and University of Konstanz project partners are investigating the influence of co-diffusion on the material quality. The aim here is to develop process sequences for as many multicrystalline silicon materials as possible. They are intending to use APCVD and co-diffusion to produce multicrystalline silicon for cost-effective bifacial solar cells. Another goal of the researchers is to greatly simplify the thermal furnace technology required for the diffusion process. The comparatively complex ovens and automation systems currently used would no longer be needed if the wafers for the diffusion process can be stacked on top of one another.

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