

## Higher solar cell efficiencies taking benefits of IC technology experience

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By bringing expertise of the semiconductor industry to the PV industry, we can significantly increase the efficiency of crystalline silicon solar cells. Of course, the semiconductor processes cannot simply be copied into the PV lines. They must be adapted towards higher throughput and lower cost. This is a challenge but also an opportunity for both tool suppliers and PV manufacturers. Research institutes such as imec can be the place where both parties meet to realize the tools and processes for high-efficiency, large area solar cells.

But let's illustrate the above statement with a few examples. First of all, doping profiles in silicon solar cells today are realized through diffusion. Ion implantation – a technique used routinely in IC manufacturing – is a promising alternative to better control the dimensions of these doping profiles while skipping a number of the current process steps.

Next, there is atomic layer deposition which is a likely candidate to passivate the surface of c-Si solar cells using  $\text{Al}_2\text{O}_3$ . Today, passivation schemes based on dielectrics such as silicon-nitride are used, but these do not suffice for thin cells (<180 $\mu\text{m}$ ). ALD concepts for the solar cell industry are being developed – being faster and more cost-effective than the original semiconductor-type of ALD. One of these concepts is the ultra-fast ALD concept based on a spatial separation (instead of temporal separation). This illustrates well that some players in industry clearly see the need for semiconductor expertise in the PV process flow.

A third example is the replacement of Ag as top contact material by the less scarce and cheaper Cu material. Instead of screenprinting the Ag pastes, Cu is typically deposited by electroplating, a technique well known in other industries. The use of Ni in combination with Cu provides an adequate barrier to prevent Cu from reaching the active silicon. The microelectronics industry has built up a lot of experience on this topic since Al was replaced by Cu as interconnect material about a decade ago. Starting from this existing microelectronics experience on Cu metallization and related barriers, it may become possible to develop reliable solutions for Cu metallization in crystalline silicon solar cells in a short term..

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Next to these three examples, effective cleaning and handling methods are required to minimize metal contamination. In addition, more precise and low cost patterning methods are required to cope with more complex cell patterns and device concepts like interdigitated back contacted cells. And of course, the multitude of analytical tools and techniques developed for the semiconductor industry are also relevant in the development of next-generation high-efficiency crystalline silicon solar cells.

As you can see, there is a multitude of knowledge and techniques available to boost solar cell efficiencies. But it's only a starting point from where PV industry, semiconductor experience, tool suppliers and research institutes can relaunch their quest towards the best possible cost effective crystalline silicon solar cell. Because that's what the world needs to shift to a green future.

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