Fraunhofer ISE

Press Release

Freiburg
September 2, 2011
No. 26/11

Cost-Reducing Concepts for Solar Cell Metallization

Long-Term-Stable Copper Metallization and Industrially Feasible Processes Have Enabled 21.4 % Efficiency

Reductions in the electricity generation costs for photovoltaics can be reached through two mechanisms: improving the efficiency of solar cells and reducing their production costs. With advanced processes for metallization of solar cells, both effects can be reached at the same time. In the ETAlab® at Fraunhofer ISE – the laboratory for new solar cell structures and processing steps – the technology of producing solar cell contacts 100% from low-cost materials has been achieved. In doing so, industrially feasible galvanic processes were used and expensive silver has been replaced, mostly by copper. The researchers achieved a solar cell efficiency of 21.4% using this approach. Especially remarkable: this result is comparable with values from solar cells using a highly efficient titanium/palladium/silver contact system, which must be created in comparatively expensive vacuum laboratory processes.

In order to achieve high solar cell efficiency values, the front contacts must conduct the electricity created upon illumination as loss-free as possible, and at the same time cover as little cell surface area as possible. From a technological point of view, only materials with the highest conductivity can be considered for this task, especially copper and silver. In the current standard process, silver-based pastes are used to create relatively broad and porous contacts via screen printing. With the enormous cost difference between silver and copper, simply by changing the material and keeping the efficiency the same, it is made possible to reduce the production costs by about 8 cent/WP,

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or in other words, by up to 10 percent. Copper can be deposited from chemical solutions in galvanic processes, which are economical and have high rates of deposition. If the solar cell efficiency is further improved with such industrially feasible processes, the advantage of the specific costs will be even higher.

The challenge of the solar cell metallization with copper lies in the creation of a homogenous and qualitatively high-value layer between silicon and copper. This serves as a barrier against diffusion of copper into the semiconductor. Effective prevention of copper diffusion is decisive in order to ensure the loss-free operation of the solar cell. For this purpose, the researchers used nickel. Nickel can, in addition to the required barrier function, also create an electrical contact to the silicon. Furthermore, it offers the advantage that, like copper, it can be deposited onto the solar cell with low-cost galvanic processes. A galvanic nickel-copper system on printed silver contact layers, the current standard process of the industry, is a first possible use for this reason. With only minor adjustments to industrial production lines, the costs here can be dramatically reduced.

An even greater efficiency potential for solar cells is provided by the galvanic nickel-copper system with direct deposition to silicon, without a printed silver contact layer. Using an industrially feasible process, such as laser ablation, the anti-reflection coating (ARC) is removed locally. Structural widths in the range of 20 µm are achieved, which significantly reduces shading in comparison to screen printing. In the affected areas of the ARC, nickel will be selectively deposited, which is then reinforced and made solderable by the addition of copper and zinc or silver. On solar cells with front and rear side passivation in a 2x2 cm² format, this technology reached an efficiency of 21.4% in ETAlab®, which was confirmed by CalLab PV Cells at Fraunhofer ISE. "Our copper-metallized solar cells from the ETAlab® are not only comparable with the efficiency of the

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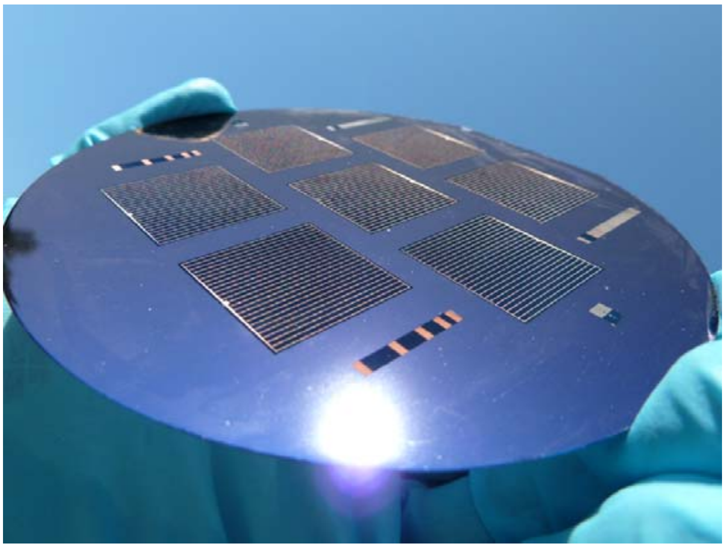
titanium/palladium/silver reference technology, but also show an excellent stability in long-term tests. A thermal stress test of 1600 hours at 200 °C had no consequences for the efficiency", says Jonas Bartsch, Team Leader "Plating Process Technology".

With the process knowledge built up at Fraunhofer ISE, the researchers at the ETAlab® are working on transferring this technology to large solar cell formats. "The metallization based on copper and nickel offers a significant potential for cost savings for the next generation of silicon solar cells, and with it for power from sunlight", says Dr. Markus Glatthaar, Head of Group "Advanced Processes".

Fraunhofer ISE also presents the topic of long-term stable copper metallization at the 26th European Photovoltaic Solar Energy Conference and Exhibition from 5-9 September in Hamburg (Hall A4, Stand C11).



High-efficiency solar cells (21.4 % efficiency at 2x2 cm²) with long-term-stable copper metallization from the ETAlab® at Fraunhofer ISE. ©Fraunhofer ISE

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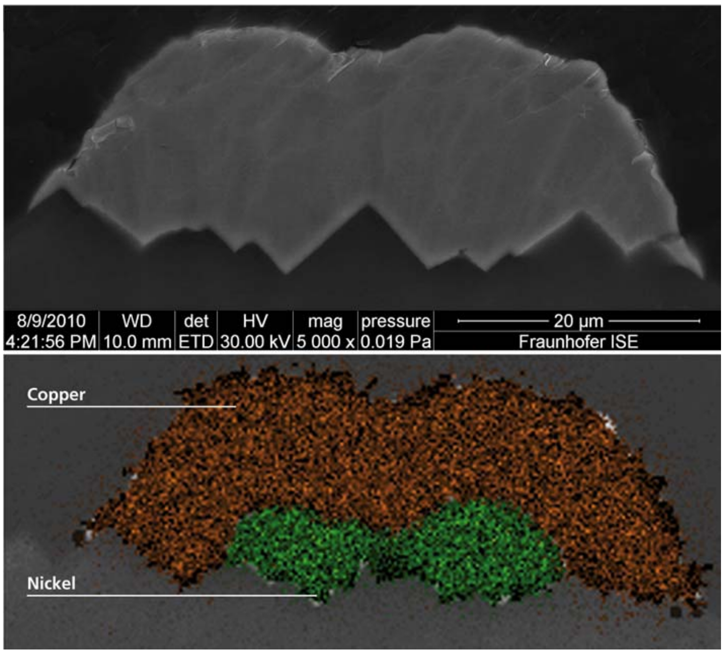

Cross-section SEM image of one of the silver-free high efficiency solar cell contacts produced at the ETAlab® of Fraunhofer ISE (above) and corresponding EDX analysis of the chemical elements. ©Fraunhofer ISE

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