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Fraunhofer spin-off for photovoltaics

Out with the silver, in with the copper: A new boost for solar cell production

The rising price and low availability of raw materials, especially silver, are leading to higher costs in producing photovoltaic modules. Fraunhofer researchers have developed an electroplating process that involves substituting silver, an expensive precious metal, with copper, which is more readily available. They have also succeeded in replacing the polymers that are usually left over after electroplating processes, and are expensive to dispose of, by instead using easily recyclable aluminum for masking. In order to bring the technology to the market more quickly, the spin-off PV2+ was launched.

When it comes to generating electricity from renewable energies, photovoltaics are a mainstay. Modern heterojunction solar cells have a particularly low CO₂ footprint on account of the low amounts of silicon used to produce them, and when it comes to industrial production, they achieve the highest levels of efficiency. As a result, the chances are high that this technology will become the standard in production. There are figures to show the growing importance of photovoltaics. According to the International Renewable Energy Agency (IRENA), more than 96 TWh of energy was produced by photovoltaic systems worldwide in 2012, which rose to nearly 831 TWh by 2020. According to the German Environment Agency, the amount of electricity generated from photovoltaics in Germany rose from almost 27 TWh to almost 50 TWh in the same period.

This is by no means the limit of what photovoltaics can offer. However, when manufacturing solar cells, valuable silver is used for busbars and contacts, which conduct the electricity that is generated in the silicon layer by means of solar radiation. The cost of this precious metal is rising — even today, silver accounts for around 10 percent of the manufacturing price of a photovoltaic module. Moreover, there are only limited quantities of the metal available on Earth. The solar industry processes 15 percent of the silver mined, but due to the industry's high growth rate, this proportion is set to rise sharply. This will not be viable, however, as other sectors such as electromobility and 5G technology also report an expected future increase in their use of silver. That is why the solar industry requires breakthrough technological innovations to realize its full potential.

Copper for solar cell contacts

Researchers at the Fraunhofer Institute for Solar Energy Systems ISE have taken on this challenge. With about 1,400 employees, this Freiburg-based institute is the largest solar research institute in Europe. A team of researchers led by Dr. Markus Glatthaar, an expert in metallization and structuring, has developed an electroplating process for the

Contact

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promising heterojunction technology to replace silver with copper. Copper is many times cheaper and more readily available than silver.

To ensure that the electrically conductive surface of the solar cell is not completely electroplated with copper, the areas of the surface that should not be coated must first be masked. These areas are covered by a coating that has an electrically insulating effect, thereby preventing them from being electroplated. The copper layer will only build up in the areas not coated with the insulation.

The researchers have made another significant advance here: Until now, expensive polymer-based lacquers or laminated foils have been used in this industry to mask the silicon wafer in the electrolyte bath. Properly disposing of the polymers is an expensive process that generates a lot of waste. Dr. Glatthaar and his team have been able to substitute the polymers with aluminum. Just like copper, aluminum is fully recyclable. Switching the materials twice, from silver to copper and from polymer to aluminum, also brings twice the benefit: Producing solar cells is not only more sustainable, but also significantly cheaper.

A scientific breakthrough: innovative electroplating and improved electrolytes

But how did the researchers manage to replace silver, an expensive precious metal? "We developed a special electroplating process that makes it possible to use copper instead of silver for the busbars," explains Dr. Glatthaar. This even improves conductivity — the copper contact lines are particularly narrow on account of their laser structuring. Due to the copper line's extremely small width of only 19 μm (micrometers), the light-absorbing silicon layer experiences less shading than with the silver lines. This and the high conductivity of electroplated copper improve the electricity yield.

The Fraunhofer team has also made a second technological achievement in using aluminum as a masking layer. The difficulty here is the electrically conductive nature of aluminum, which renders it at first glance unsuitable to use as a mask. The Fraunhofer researchers took advantage of the fact that aluminum can form an insulating oxide layer on its surface. However, this layer is only a few nanometers thick. "We were able to adapt the process parameters and develop a special type of electrolyte which ensures that the aluminum's extremely thin, native oxide layer can reliably fulfill its insulating function. This was an important milestone for the success of our research project," Dr. Glatthaar is pleased to report.

As recyclable materials, both copper and aluminum can bring photovoltaic production much closer to the circular economy, improving environmental and social standards in the process. "Given that we have sufficient supplies of copper in Germany, the supply chains are much shorter and the price is less dependent on international raw material markets or foreign suppliers," adds Dr. Glatthaar.

Spin-off PV2+ brings solar technology to the market

In order to bring the promising technology to the market more quickly, Fraunhofer ISE launched the spin-off PV2+. The letters "P" and "V" stand for photovoltaics, with "2+" indicating the double positive charge of copper ions in the electroplating bath.

The company is also based in Freiburg, with Fraunhofer researcher Dr. Glatthaar acting as CEO. He is aiming to set up a pilot production plant together with industrial partners as early as the start of 2023.

As Prof. Andreas Bett, institute director of Fraunhofer ISE, explains: "These innovative solar cells are an important stepping stone on the way to a future power supply based on renewable energies. They will give the photovoltaics industry a much-needed boost. The spin-off has huge potential to quickly and successfully establish itself on the market. And of course, we are particularly pleased that these technologies were developed at our institute." What's more, the German Federal Ministry for Economic Affairs and Climate Action (BMWK) is funding the project as part of its start-up program Exist.

[Spin-off PV2+](#)

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Fig. 1 At just 19 micrometers in width, the copper contacts are extremely thin. As a result, the light-sensitive silicon layer does not experience much shading.

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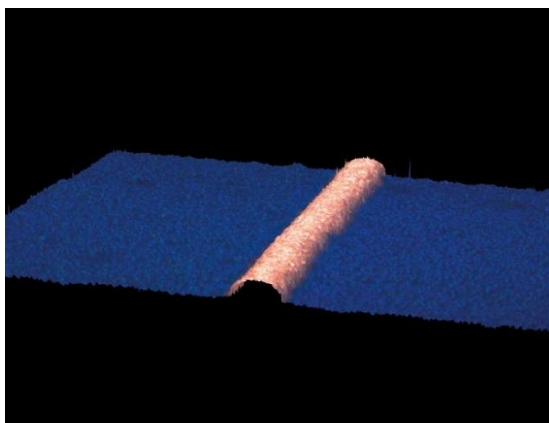


Fig. 2 Three-dimensional confocal microscopy image of a copper contact produced using the laser-assisted process developed by PV2+. The even, semi-circular shape of the contact ensures a high level of electrical conductivity.

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