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View INDEX on Pages 68 & 69

Façades, the Focal Point

Wafer-thin solar cells transform glass fronts into power plants. Cities are eating up an increasing amount of heat and electricity. In order to reduce this consumption, buildings have to become increasingly efficient and integrate more renewable energies. New, printable photovoltaic semi-conductors could help to boost this trend. They enable solar films and modules to be produced, which transform windows or façades into electric power generators. A new market is being created for the manufacturers of solar glass and modules.

The race for the best solar cells material has a new candidate: Perowskit. No other semi-conductor has enabled researchers to succeed in achieving such a dramatic development in efficiency levels. "There is now an absolute hype surrounding Perowskit," says Thomas Unold, head of the Institute for Technologies (Institut für Technologien) at the Helmholtz-Centre Berlin.

The mineral promises to be efficient and at the same time inexpensive. Up to now it has not been possible to combine both these characteristics: currently the best silicon cells achieve an efficiency level of over 20%, but are expensive to produce. Pigment and organic solar cells in turn can simply be printed on film, but often do not exceed an efficiency level just over ten percent.

With a Perowskit cell in contrast, the researchers at the University of California in Los Angeles (UCLA) recently achieved an efficiency level of 19.3 percent. Compared to the first Perowskit cells five years ago, the efficiency level has thus increased six-fold. This is all the more remarkable as Perowskit can be easily and very economically processed. It consists of the universal commodities carbon, nitrogen, hydrogen, lead, chlorine and iodine, which can be vapor-deposited onto glass as a wafer-thin layer or printed on film and foils. The UCLA researchers produced a Perowskit layer of just around one millimeter thickness by vaporizing glass with organic molecules and lead crystals. Nevertheless, the cell generates almost as much electricity as a 180 micro-meter thick silicon cell.

As a result, the high-performance

Photo: Heliatek / Smack Communications, Berlin

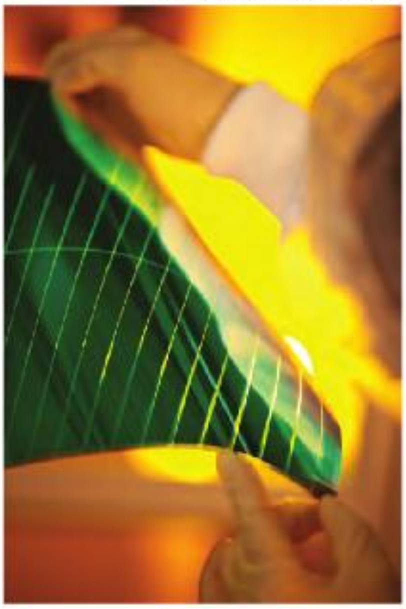
Transparent power plant: Transparent solar films can be laminated in between window panes. This produces tinted glazing, which at the same time provides shade and eco-electricity.

light-weights could conquer the markets which were previously, to a great extent, taboo for photovoltaics. Building integrated photovoltaics for example, in short BIPV continues to be just a niche market, because the manufacture and installation of multi-functional BIPV modules is costly and expensive. Of the 3,300 Megawatt solar power output, which went online in 2013 in Germany, it is estimated that only around 100 Megawatt was integrated in building shells. A market inhibitor: the BIPV elements are mostly project-orientated variations, which in terms of size, form, material, colour, varying transparency and design, are adapted to the respective building – individuality and the high planning expenditure have their price. Perowskit cells could help to reduce costs.

In addition, the technologies which come into consideration for BIPV have previously not been efficient enough. Often modules made of thin-layer silicon are available, but they rarely reach an efficiency level of 10% – too low to be able to compete with classic silicon cells on the roof, which convert almost twice the amount of light into electric energy. They themselves are only suitable to a certain extent for building integration: they are sawn straight out of blocks because they are simply too thick and inflexible for more complex BIPV applications.

Nevertheless experts are hoping for an imminent breakthrough in building-integrated photovoltaics, because it harbors immense climate protection potential. Although major cities only account for one percent of the Earth's total surface, they consume 75 percent of the primary energy used and cause 80 percent of greenhouse gas emissions. "With a large part of their processes they have to be carbon dioxide-neutral,

Photo: Heliatek / Tim Deussen, Berlin



Thin, light and supple: Heliatek vapour-deposits a photoactive film in wafer-thin form onto a carrier film. The film can thus be used almost without any limits to produce electricity.

Photo: IBA Hamburg GmbH / Johannes Arlt

Algae house: In the façade of the "House with Bio Intelligent Quotient" in Hamburg algae use photosynthesis to produce heat for the apartments.

otherwise there is a threat of climatic collapse", warns scientist Christina Sager from the Fraunhofer Institute for Building Physics (Institut für Bauphysik - IBP) in Stuttgart. In her view more efficient buildings and renewable energies could bring about the trend turnaround. She said that solar technology, in particular, could be effectively integrated in houses. Where the modules could not be fixed to rooftops, they could serve as power-generating windows or as a substitute for the concrete façade, Sager explains.

However, until the promising Perowskit cells can be used commercially, the researchers still have to master several challenges. "The development is just beginning", says Helmholtz researcher Unold. The service life is regarded as the greatest hurdle. Perowskit is sensitive and quickly degrades when it comes into contact with water. For that reason the cells must be designed in such a way, that even over a period of 20 years no moisture must be allowed to penetrate them. Leak-proof encapsulations, which were developed for organic light-emitting diodes are one possible solution.

In the meantime other promising technologies, which are currently ready for market introduction, have been able to drive forward the BIPV market. Dresden company Heliatek for example has developed an organic photovoltaic film, which can be produced both in transparent as well as tinted form. In non-transparent form it reaches an efficiency level of twelve percent, while the translucent variation has a reduced efficiency level down to around seven percent. Compared to conventional silicon modules this is low, but in the area of organic photovoltaics it sets a new record. In addition, the flexible films can be embedded in curved formats such as glass car roofs or irregularly formed façades. "As dimming films are, as a rule, also in demand in vehicles and offices, there is no additional maintenance expenditure", argues Heliatek boss Thibaut Le Séguillon. "As a result, competitive prices are possible." he said.

Other companies are also banking on the concept of flexible and transparent cells in organic material. The Bavarian company Belectric as well as Crystalsol from Austria for example are working on printed polymer cells. Polymers are chemical combinations of long molecule chains, which can be enriched in a solution and then printed. Heliatek in contrast uses oligomers as light collectors, in other words shorter molecule chains. In addition, it does not print, but vaporizes them in a vacuum onto a carrier film. Currently Heliatek is still operating pilot production. With solar films from this production line the company has just set up the first window façade in Dresden. The next step planned by the company is commercial production with an annual capacity of 100 Megawatt.

With BIPV a key, new area of operation could also be created for the glass industry. Among the module producers questions are being raised which they can only answer in cooperation with the glass sector: How can the solar films be integrated in the panes? How can the integration be effected as cost effectively as possible? Can work steps such as vapor-depositing on the photoactive materials be integrated in the glass finishing? "BIPV has not yet really asserted itself. But it is definitely essential for the glass and photovoltaics industry to come closer together", says Timo Feuerbach from the Glass Technology Forum (Forum Glastechnik) within the German Engineering Federation (VDMA). The first cooperations are already in place. In this connection, Heliatek and Brussels-based flat glass manufacturer AGC Glass Europe last year concluded a development agreement for the integration of solar films in construction glass. AGC technology boss Marc Van Den Neste says that the glass/solar façade solution created by the two companies is opening up completely new possibilities for the architects and designers to combine creativity and energy efficiency with each other.

It is not only due to the cooperation with Heliatek that AGC Europe is regarded as a trailblazer for the glass industry. Its factories are home to a fully-integrated production line which not only covers the production of glass but also its coating and further processing. Various functional coatings are available to photovoltaics

Photo: BSW-Solar / Paul Langrock

Field-tested showcase project: The roof of Berlin's main rail station clearly illustrates the advantages of BIPV: the modules generate electricity and at the same time transmit light.

manufacturers, for example electrical contact layers for thin-layer modules. A similar solar-orientated concept has otherwise previously been pursued solely by East German company F-Solar. They, too, have extended their production line at their own company to include coating systems.

At glasstec 2014 in Düsseldorf, from 21 to 24 October 2014, the world's largest and most international trade fair for the glass sector, companies will have the opportunity to pave the way for further cooperations. In this connection, experts from the solar power and glass industry will come together from 20 to 21 October 2014 at the "Solar meets Glass" conference to enter into an exchange about advances in the production of solar glazing and modules as well as the material and costs. The "glass technology live" special show, which has been organized by the Institute of Building Technology, Construction and Design (Institut für Baukonstruktion) at Stuttgart University, is focusing among other things on the interface between solar technology and glass. Here, using the example of large-format façade mock-ups and scale models, the latest developments in the façade and energy sector are presented, including innovations in photovoltaics and solar thermal energy.

At "glass technology live", however, projects will also be presented which extend beyond pure solar applications. Such as for example the so-called BIQ – the abbreviation stands for "House with Bio Intelligent Quotient". In its bio-reactor façade algae grow on glass panels and use the combination of light and carbon dioxide to produce biomass and heat. The heat is supplied to the 15 apartments directly for heating purposes via heat exchangers, while the bio mass is skimmed off. It is used to obtain biogas, converted by a fuel cell into electricity and additional heat. All the energy required to produce electricity and heat is created from regenerative sources, fossil fuels are not used, according to the construction company responsible for the project, Otto Wulff.

Energy-generating house façades such as those demonstrated by the BIQ could play a key role in the energy turnaround in the cities. Researchers and companies are working flat out on concepts and technologies, which transform building shells into efficient power stations. In this process the glass industry could assume a key role. By working more closely with the manufacturers of solar modules and collectors it could further accelerate innovations.

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