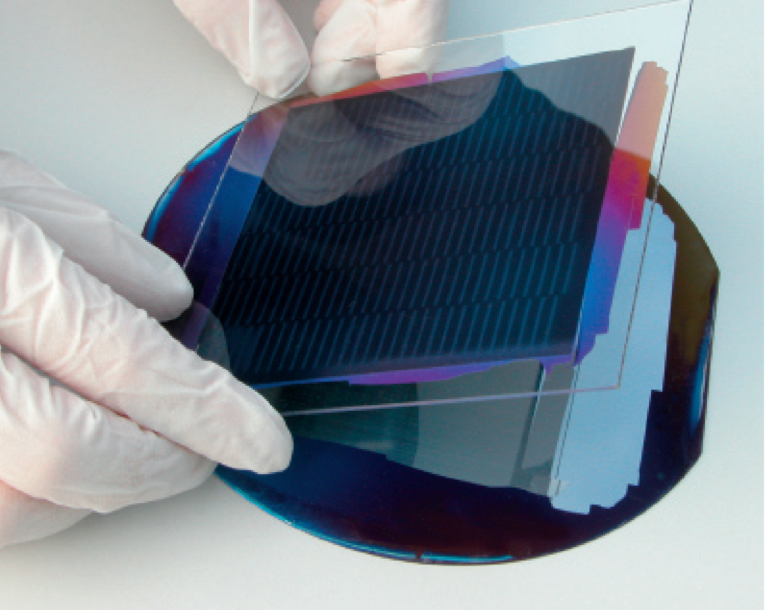


Peelable solar cell: A member of the ISH team presses an adhesive-coated piece of glass onto the extremely thin crystalline silicon layer and peels it off the wafer.

Slimming Diet for Solar Cells

A sophisticated method makes it possible to manufacture efficient solar cells from thin layers of silicon

IT IS BASICALLY a matter of saving – saving on expensive crystalline silicon in solar cells. Former Max Planck scientist Rolf Brendel, who now heads the Institute for Solar Energy Research in Hamelin (ISFH), developed the porous silicon process (PSI process) for this purpose. The process can be used to manufacture monocrystalline silicon solar cells that are extremely thin and thus save on material.

The scientists process a surface-textured wafer of porous silicon in such a way that they can coat it with a thin layer of silicon. Wafer solar cells are normally between 250 and 300 micrometers thick because they are usually sawn off of silicon rods. Cells manufactured in the PSI process, on the other hand, are a mere 20 to 30 micrometers thick, yet they achieve an efficiency of over 15 percent. “The efficiency factor is one of the best for thin-film solar cells,” says engineer Renate Horbelt, who works together with Brendel at the ISFH.

The thin monocrystalline silicon film is separated from the porous wafer at a sort of predetermined breaking point. The wafer is cleaned, receives a new surface structure – and serves once again as the propagation bed for solar cells. A wafer can be used in this way many times.

“We are now focusing on getting the method to work reliably also over large areas,” says Horbelt. The method has already been tested in practice: for manufacturing mini-modules for solar powered wristwatches, for example. The technology is also suitable for manufacturing low-cost photovoltaic modules.

Tina Heidborn | MI 1201-2288-GBC

Border Control between Terminals

New types of membranes make fuel cells more efficient

THEY OFFER BETTER CONDUCTIVITY and are more stable and less permeable to water: sulfonated polyphenylensulfones could take fuel cells a great step forward – as a new material for membranes.

The membrane serves to separate the fuels, such as hydrogen and air, that are consumed at the two terminals of the cell – producing water as the only end product. But the membrane must also offer good proton conductivity. When the fuel cell produces electricity, protons – positively charged hydrogen atoms – are generated on one side of the membrane and consumed on the other. If protons were not able to pass through the membrane, the reactions in both half-cells would come to an abrupt halt. But instead of being open only for protons, conventional membrane materials also let a lot of water through.

“Our material has extremely favorable properties as far as proton conductivity, water transport and stability are concerned,” says Klaus-Dieter Kreuer, whose research at the Max Planck Institute for Solid State Research in Stuttgart includes new membrane materials. Membranes made of this material could also increase the efficiency of the cells.

Although fuel cells now already convert energy with an efficiency of around 50 percent, and are thus relatively efficient, they still lose a lot of energy in the form of heat. And since the

left | A wash before the measurement: Vladimir Atanasov prepares a membrane for a conductivity test by acid-treating it, washing and drying it and then wetting it with a precise amount of liquid.

right | To determine how well protons diffuse through the sulfonated polyphenylensulfone, Carla Cavalca de Araujo drives them down into the superconducting magnets of an NMR machine.

Photos: MPI for Solid State Research (bottom), ISFH (top)

membranes currently employed are heat intolerant, fuel cells must be cooled. Heat-resistant membranes would require less effort to cool.

Higher operating temperatures would also be advantageous for the activity of the noble metal catalysts that boost the reactions at the two terminals of the fuel cell. At the same time, the danger of carbon monoxide poisoning of the catalysts would be reduced. The hydrogen is usually produced from natural gas and contains slight traces of carbon monoxide. Since the gas adsorption on the catalysts is lower at higher temperatures, the cell's tolerance for the poison increases – so the hydrogen gas would not need to be purified as thoroughly.

The membrane material that is most commonly used today, however, allows only low-temperature fuel cells to operate at temperatures below 90 degrees Celsius. "A 20- or 30-degree higher operating temperature would bring the fuel cells a great deal closer to economic viability," says Kreuer.

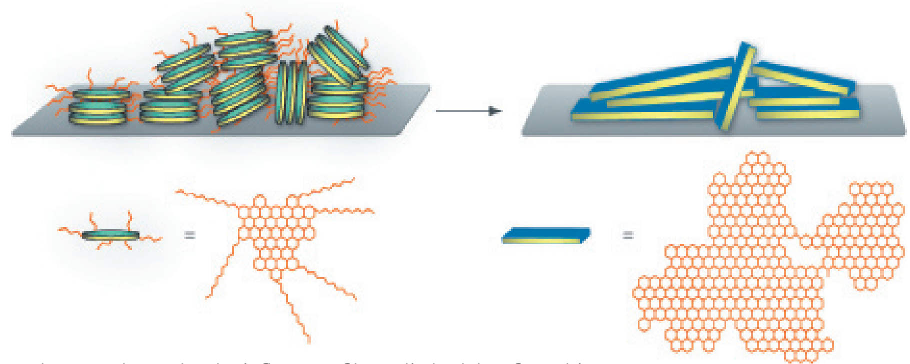
The material does exist now, and scientists are still optimizing its manufacture in cooperation with the company Fumatech. Since sulfonated polyphenylensulfones are very brittle, they must be processed as part of a composite. Kreuer and his colleagues hope to have found a viable method in three to four years. The new proton conductor could then be used not only in fuel cells, but also in batteries, seawater desalination plants, antistatic screen coatings, and for dialysis.

Tina Heidborn | MI 1201–3419–GBC

Photo: MPI for Solid State Research (bottom), illustrations: Christoph Schneider, based on material from the MPI for Polymer Research (3)

A Window for Solar Power

Transparent graphene electrodes could make solar cells cheaper and more efficient



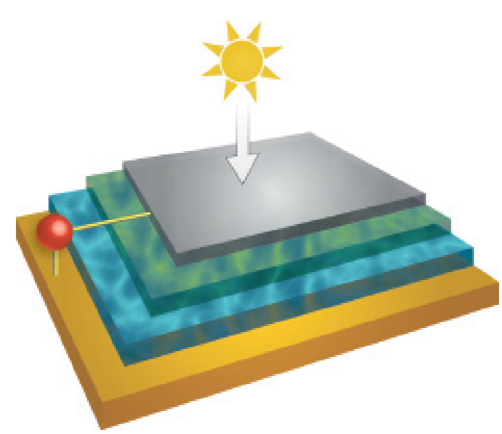
Carbon puzzle: Under the influence of heat, little slabs of graphite with hydrocarbon chains attached (left), combine to form larger graphite layers (right).

IN PRINCIPLE, one need only scribble on paper with a graphite pencil. This simple act already produces piles of graphene on the paper – individual layers of carbon atoms that are arranged in a honeycomb lattice structure. Graphene conducts electricity, and thus heat, surprisingly well, and is therefore considered to be a promising material for electronics components, which are becoming smaller and smaller.

It is no wonder, then, that researchers around the world are working on different methods to produce graphene. Simply scribbling with graphite pencils does not give them the necessary control, and the graphene layers produced in this way are too thick. Researchers working with Klaus Müllen, Director at the Max Planck Institute for Polymer Research in Mainz, have thus patented a number of methods, including one for pyrolysis. This involves heating up, on a glass support, precursor molecules that already contain small graphene disks, but that also have branches of hydrocarbon chains. As a result of the heat treatment, a transparent graphene film less than 10 nanometers thick is produced.

Films made of graphene can offer a low-cost alternative to indium tin oxide, which serves as the transparent electrode for solar cells. Although indium tin oxide is transparent and a very good conductor, it is becoming increasingly expensive, as the supply of the raw material indium is limited. In addition, transparent graphene electrodes can also make solar cells very efficient. In contrast to indium tin oxide, it is even transparent to a certain portion of infrared sunlight, which makes up around half the solar radiation that reaches the Earth. The graphene electrodes have already proven their advantages in the first solar cells the Mainz-based researchers constructed for test purposes.

Tina Heidborn | MI 0903–3685–ZLC



Solar cells, a matter of layers: The photovoltaically active materials, such as dyestuffs and titanium dioxide, lie between two electrodes – the top one must be transparent.

Photo: Norbert Michalke

"We're making biocoal economically viable"

Volker Zwing is the manager of CS carbonSolutions, which was founded one and a half years ago. The company owns the exclusive rights to use the patent portfolio of a biomass conversion method that was developed at the **Max Planck Institute of Colloids and Interfaces** in Potsdam. We spoke to Volker Zwing about how far the practical realization has come.

You are using a process that Max Planck researcher Markus Antonietti developed three years ago, attracting a great deal of attention: hydrothermal carbonization. What exactly is this?

Zwing: The process converts biomass into coal and coal-like products under pressure and at a high temperature. In contrast to other biomass methods, which very often require dry biomass, we can, or better, we want to use wet biomass, because the process occurs in water anyway. This means that we can use biomass that currently cannot be used practically, and that is sometimes even a problem to dispose of.

What are the greatest difficulties in its industrial realization?

Zwing: The core problem is the energetics: the process itself is exothermic, meaning the reaction releases energy. And this released energy must be controlled intelligently in order to use it again to create a self-sustaining process – otherwise it is of no economic interest. With the classic pressure cooker principle, where energy must be supplied from the outside for every new filling to get the process going, you can prove that hydrothermal carbonization works in principle. But of course this makes no sense energetically.

How do you solve the problem?

Zwing: In my opinion, it can be solved only by operating a non-stop – that is, continuous – process. With this principle, we're making biocoal economically viable.

What end products result from this biomass conversion?

Zwing: The spectrum is very broad: Biocoal can be used in a variety of forms, right down to carbon-based industrial admixtures, such as those used in manufacturing tires. In the simplest case, the biocoal could be burned, but it is actually too valuable for this. We are rather aiming to use it as a material: as alternatives to coal products that are currently produced from fossil coal, such as filtering charcoal or metallurgical coal. A further possibility that is currently being researched extensively is the use of biocoal as a soil conditioner. This has the potential to bind carbon dioxide in the long term. Exactly which products result from the process also depends on how the process is managed and on the biomass that is fed into the process.

You are currently building a pilot plant. When will it be ready for operation?

Zwing: The pilot plant is slated to start up this year. If it works as we envisage, the first pre-series plants will go into operation next year. We have already had extensive talks with partners, for instance with local governments that are looking for alternatives for the disposal of their organic waste, green waste or sewage sludge. We have also spoken with agricultural businesses where a large amount of cattle manure is produced. People in industry are also interested. The idea is that our company will not only supply the machines, but operate them jointly with our partners, particularly during the first few years, to ensure the quality of the method.

The interview was conducted by Tina Heidborn.