plastic & new-generation photovoltaics news

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Blinds get solar upgrade

Researchers at Imperial College, London, are developing a new, commercial version of gallium arsenide solar cells, whose main use is on satellites.

Work has begun on a prototype – the first version produced will track the sun on one axis, and the second on two. Keith Barnham, leading the research at Imperial, predicts that the company will have a working device in nine months, with commercialisation following nine months after that.

The cells, which can reach twice the efficiency of conventional crystalline silicon, will be incorporated with blinds for use on tall, glass-clad buildings.

'There is a lot of glare in buildings like this, and a very high air conditioning requirement,' says Barnham. 'These buildings – such as the 'gherkin' in London, have blinds which track the sun.'

The group, which includes a partner who makes conventional tracking blinds, has formed a spin-off company, Solar Structure, to commercialise the devices.

'We're currently in talks with a big player in the glass façade business, which is interested in the technology,' says Barnham.

'The idea is that we'll go to industry and demonstrate the technology, and hopefully people will pay a bit extra to get solar power,' says Barnham. 'Compared with the passive tracking blinds, initially there will be around a 25% price increase for the powered versions.'

The tracking blinds will have semi-transparent Fresnel lenses, which act as concentrators for the sunlight. Optical fibres will then take the light to the 1mm^2 cells at the edge of the window.

The cells are tiny, and the lenses concentrate available light by 500 times, with a 20% ultimate efficiency the goal including the optics. 'The advantage of the system is that you can generate electricity at peak usage, and reduce air conditioning needed,' says Barnham. 'The blinds will let the diffuse light through, but will stop glare – so you don't need to have the lights on.'

If the technology can be mass produced, Barnham says it could be used in homes as well. The cell would easily fit inside double glazing.

The solar cells will be produced using the same equipment as for LEDs and lasers, thus reducing costs.

Norman Britland, director of UK-based Blind Design, says that the concept is a good one, and that his company would be interested in it. 'You'd need to look at the details though,' says Britland. 'Such as, what are you going to do with the power?'

Click here for more about Imperial College London

A question of efficiency

Gallium arsenide is an inorganic compound that can achieve over 35% efficiency in the right conditions. It's expensive, but in space the weight to power ratio is important enough to bear this cost. Satellites use complex, triple junction solar cells, made by companies such as Spectrolab. Barnham and his partners have achieved 26–27% efficiencies using x500 concentrators with a single junction cell. This compares well with thin film silicon, which drops to around 7% to make it transparent – and won't prevent glare. Barnham is now working to reduce the bandgap of the materials, to widen their spectral range, and increase the efficiency further.

In this issue ...

Next-gen photovoltaics could aid developing countries

Cost-effective solar cells could be vital in solving the shortage of clean power in developing countries – which has got worse in 2006.

That's the view of REDCO (rural energy delivery companies) alliance members, a consortium of companies whose goal is to promote and facilitate solar power in Latin America, south Asia and Africa.

'Organic solar cells are applicable in the third world,' says Titus Brenninkmeijer, head of California-based Solgenix, and founding member of REDCO. 'If you add up the numbers, solar energy works out better than conventional methods. But getting the technology cheap enough to the point where people can afford it is a big issue.'

'The average size of systems in the third world is 60–70 watts, so less efficient but bigger cells would be an advantage,' Brenninkmeijer explains. 'People would be prouder to have a larger panel on their hut or business roof, and it would help the problem of theft, since they'd be harder to run off with.'

Harish Hande, MD of SELCO-India, another alliance member, agrees. 'New generation photovoltaics will absolutely be important and they could have a big impact. But all the other linkages need to be put in place for it to work,' he says.

Brenninkmeijer and Hande describe how local manufacturers, by supplying external rather than domestic markets with high-power modules, have made it hard for people to get affordable solar solutions.

'This year has been a disaster because of export markets,' says Hande. 'Manufacturers here are making different cells to meet the German market, which are larger and more expensive than those needed for people here in India.

'There has been a 47% increase in the price of the cells, and it's unethical for me to pass that cost on to my customers. German people have a choice – people in the third world don't.'

Brenninkmeijer adds: 'PV is vital in areas with no grid, and where there won't be one. It's a huge aspect of public health – clean energy means no fumes and purified water.'

PVs even have an impact on education – many children in the third world work in the day and go to school at night, where lights are needed. 'Children in Haiti gather round gas stations at night to do their homework,' says Brenninkmeijer.

REDCO (rural energy delivery companies)

The REDCO alliance was formed in June 2005 following a five-day meeting in Southern India between the 14 initial members. The alliance stated a primary goal to reach a provide energy to a total of 750,000 rural households by 2010, as well as supporting initiatives to widen energy access in developing countries. 'We're now looking at bringing in new members, and improving economies of scale and exchange of ideas,' says Brenninkmeijer. 'My personal involvement is in the steering committee of the REDCO alliance, and one of the founders of the Energy Access Foundation. We help the REDCO members and look at the needs these companies have in scaling up their technology and businesses, as a link between the developing world and the US/EU.'

Click here for more about Solgenix

Liquid crystals could be key to better charge mobility

Researchers at the Paul Pascal Research Centre, France, have created a thin film active layer using liquid discotic crystals, and will have results on charge mobility in 2007.

'People have found that these materials have good charge mobility in bulk, so we're very confident about what we'll find when measuring them through a film,' says researcher Harald Bock at the centre.

Charge mobility in the films will be tested by the Electrical Engineering Laboratory in Toulouse.

'We've had interest in the technology from a huge company, and although it'll be a few years before it's commercialised, it'll be less than 10,' says Bock.

Charge mobility is the limiting factor in organic solar cells, and Bock – with colleague Erik Grelet – is using flat layers with self-organising molecules to keep mobility high.

The liquid discotic crystals absorb the visible range of light, and are anisotropic molecules, meaning that their optical and electrical properties depend on their direction.

'By using the crystals we maintain the uniformity of the film, as well as the charge transport,' says Bock. 'The idea is to use two layers of the crystals as the active layer.'

Grelet says that the researchers now understand why orientation of the materials affects charge mobility, and that the next step is to optimise their alignment in films.

'Imagine the molecules to be flat discs,' says Bock. 'We can arrange them in semi-liquid phases so that they stack in a column. Because they are in close contact, charge transport

between them is good. If the column goes through the film, then you can get high mobility through the film.'

The next challenge was to get the column upright in the film, perpendicular to the substrate. Grelet explains that this was achieved by melting the columns through heat treatment, following by cooling at the right speed and temperature.

'When we cool the material, the discs self-assemble into column, because of nucleation at the solid interface with the substrate,' says Grelet.

'Commercialisation depends to an extent on how much we publicise it, and if we find a niche application,' says Grelet.

The cells would be particularly flexible – the material is like sticky gum, so forms can be modelled in it – and the transparency can be tuned.

'Often people don't try to orient their materials. But we found that if you don't orient the materials properly, you are in the worst position for charge mobility,' says Bock.

Click here for more about the Paul Pascal Research Centre

Nanosolar on track for 2007 commercialisation

California-based Nanosolar will open its pilot plant in 2007, and already has customers for the first two years of cell production.

'The plant will have a capacity of several hundred megawatts, and we'll be capacity limited until 2010,' says Martin Roscheisen, CEO.

Nanosolar's cells are made of CIGS, and produced using a roll-to-roll process. This will make the cells between five and 10 times cheaper than conventional crystalline silicon versions.

The company's initial target market is industrial power generation, on large commercial rooftops and in arrays.

The cells will be as durable and efficient as conventional silicon ones,' says Roscheisen. 'We have 19.6% efficiency in the lab. Manufacturing processes cut this down a bit, but our cells can compete with the high-volume segment of the silicon PV market.'

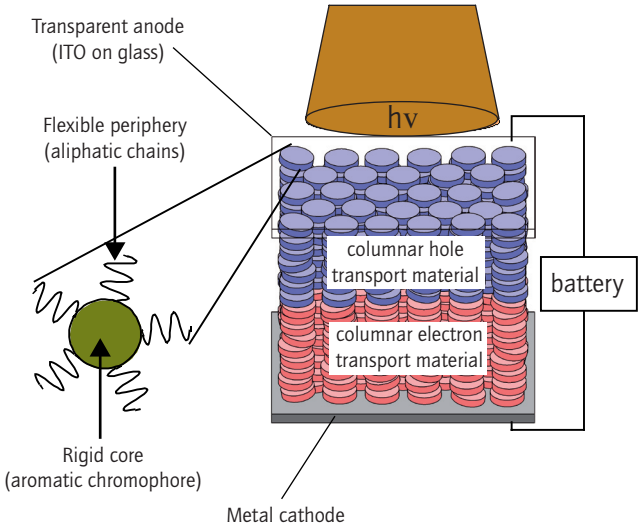
But there will be options for homeowners too. 'If solar cells are cheap enough, there's no reason why they shouldn't be on the top of every building,' says Roscheisen. 'We will also offer residential solutions, but we're still determining where the split between the markets will be.'

Nanosolar's cells are made from CIGS nanoparticles, using a mixture of conventional and specialised equipment, and can be produced 3km long if required. Roscheisen believes material supply won't be a problem due to the small amounts used: 'We use less than a few grammes of indium and gallium per square metre.'

The company expects to sell heavily in California and Europe, with sales in China as well. It will market to PV system integrators, which will on-sell to their customers. 'I think that solar power is mandatory – we can't rely on coal or other environmentally unfriendly resources,' says Roscheisen. 'Solar energy is in the papers in California every day. Governor Schwarzenegger has got a lot of credit for his ambitious environmental initiatives.'

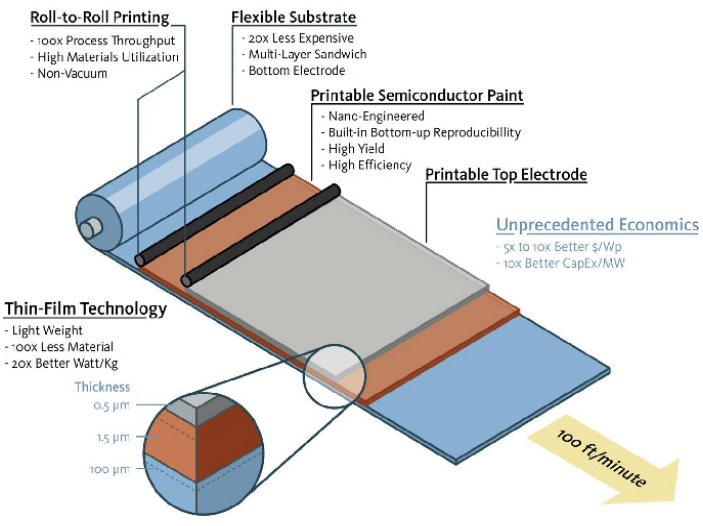
Click here for more about Nanosolar

Schematic of a solar cell based on discotic liquid crystals



Source: Paul Pascal Research Centre

Schematic of a Nanosolar cell



Source: Nanosolar

Q&A

Industry profile

Daniel Patrick McGahn

Chief marketing officer, Konarka

Massachusetts-based Konarka is developing organic, dye-sentitised solar cells, which can be printed in a high-throughput roll-to-roll process.

How much military interest is there in your technology?

We have some significant relationships with the US military, and design systems based on what they want to do. Whether it's training or combat, it's important for a soldier to have power available and accessible. The military has looked at solar solutions for many years, but what's unique about our technology is the way it looks, and the way it can be integrated. It creates something that is very familiar for people.

What do they want?

One important factor for the military is that PVs generally have a certain aesthetic – you can see it and know it's a solar cell. With our technology, camouflage can be used on the active layer itself – it can comprise of different materials that reflect different colours and have a camouflage print, for example on a tent. It looks like a tent, it can be folded and shipped like a tent, and that's what they want.

What sort of applications are they looking at?

They have begun testing devices that use our cells, one of which is a plastic foldable map. Another application could be used as a low light energy gatherer. Visualise a tent that looks like half a cylinder, which can harvest energy throughout the day.

What is Konarka's business philosophy?

We're integrating PV systems directly into devices, which are as benign as possible in size and price. It's all about allowing normal, everyday things to become PVs themselves. My basic philosophy, when I joined the company, was to find something that already exists, and find a way of affecting the value. A lot of companies want a completely new way of doing something. For example, a whole new type of music player, or book reader.

How will your technology allow you to achieve this?

We're looking reducing the module cost of solar cells by an order of magnitude. We're using standard coating and printing, tried and tested methods. The people using heavy metal PVs are trying to perfect unknown manufacturing processes. Our products start and end up as a roll of plastic.

What commercial partners do you have?

We partner with large chemical companies to develop materials, and we have relationships with Eastman Chemical, Siemens and Chevron's energy division. For commercialisation, in each licensing deal, we will have an ownership interest. We have two commercial partners at the moment, including the recent deal with G24i, and we'll get more. Not a dozen more, but we're looking, particularly in Asia and the US, where we don't have any partners at the moment.

How important is cost-effective, integrated solar power?

Our ability to do what we do is predicated on power. For example, everyone is trying to put more value in things like phones or music players. If you have video on an ipod, it will need more power. You then either have more battery, or you enable it to scavenge energy itself, such as light. It's a natural fit as well, because these devices are used outdoors. We're looking at using our cells in commercial products such as awnings. They can also be used in sensors and packaging.

Daniel Patrick McGahn, Chief marketing officer at Konarka

Prior to joining Konarka, Daniel was COO and general manager at Hyperion Catalysis, specialists in carbon nanotube development and applications. He holds a B.S. in Ocean Engineering and a Master of Engineering degree from MIT.

Click here for more about Konarka

New processing method for anti-reflective layers

A new method of creating anti-reflective layers for solar cells should be ready for industry implementation by the end of 2007.

The five-year-old project, aimed at increasing PV manufacture speed, is a collaboration between the University of New Hampshire (UNH), US, and nearby photovoltaic equipment manufacturer GT Solar.

Anti-reflective layers are a standard component of solar cell modules, used to capture as much sunlight as possible, maximising the power ultimately produced.

'We're using a plasma CVD process, for which we made new equipment,' says project researcher Carmela Amato-Wierda of UNH. 'The advantage, and newness, of the technique is that it can be done at atmospheric pressure.

'Normally vacuum processing is needed – ours is a simpler process that can be integrated into a continuous production line.'

The group is currently depositing the layers on bulk crystalline silicon, but the process can be used on any substrate – including thin-film silicon and hybrid or organic compounds.

Amato-Wierda says the group has created layers on 4cm^2 cells in the lab, and that work looks promising. Silicon nitride is used as the anti-reflective layer, but other materials can be deposited including, in theory, polymers.

'Scaling things up is the next step – we can deposit the films and optimise the conditions to get good results,' says Amato-Wierda. 'GT Solar have said that there's a lot of excitement about the technology, and I believe people are interested.'

Along with GT Solar, the project has state and Air Force funding, which will continue until the end of 2007. 'The process should be affordable,' says Amato-Wierda. 'The project came about because people said, 'wouldn't it be great if we could get rid of all this vacuum equipment."

'Renewable energies are critical. This particular technology is something that will lower the price of photovoltaics, and make them more widespread,' says Amato-Weirda.

GT Solar's director of R&D, Yue Peng Wan, believes the technology being developed with NHU will be crucial in speeding up manufacture of solar cells.

'Although our process will be cheaper than the vacuum processes conventionally used, the main benefit will come from making production faster,' says Wan. 'The typical batch processes used are inherited from the semiconductor industry, and it is the bottleneck in production.'

Click here for more about GT Solar

Solar cell provider weighs up thin film silicon

Californian photovoltaic supplier Atlantis Energy Solutions is considering providing thin film silicon installations for its customers.

The company, which supplies building integrated solar solutions, currently works with conventional bulk silicon cells.

'We're interested in working with transparent thin film silicon in windows,' says Joe Morrisey, Atlantis' East Coast Representative. 'We've met with a company that is a quality provider of this material, and which has an excellent name.'

Morrisey says that discussions are ongoing with the material supplier, but that any move into thin-film silicon will be customer driven – if a customer comes to Atlantis requiring a solution that bulk silicon can't deliver.

'We're driven by volumes of demand,' says Morrisey. 'But we have the capacity to do large scale coating of glass, so we can go forward quickly if needed.'

Atlantis works with the architectural community, where design important. 'You have different design options with thin film,' says Morrisey. 'It has a more uniform, consistent look and feel – different from conventional silicon crystal cells. We see our work as a blank canvas on which to work.'

Morrisey says that although the promise of thin film has been a long time coming, things are now moving forwards – and that it has potential for Atlantis. 'In northern latitudes, like New York City, the technology has appeal – you can put it in windows in a condo or a hotel.'

But thin film won't be the answer to everything. Often on Atlantis' projects there are issues including lack of solar cell real estate or shading on tall buildings. In these instances, high efficiency bulk silicon could still be the best option.

Click here for more about Atlantis Energy Solutions

New Energy Options

NE Options, based in the US, designs solar cell solutions in collaboration with Atlantis Energy Systems. A spokesperson for the company says NE Options believes that only if thin film photovoltaic efficiency increases a lot will the technology be a viable power generation option. 'At the moment, the efficiencies aren't high enough to advertise the technology for power generation – it's more of an aesthetic choice, and the installation costs are high,' he explains. 'But it would enable more design options – the technology can be used anywhere that glass is, and would be cheaper than marble.'

Lower band gap for better solar cells

Scientists at the Risø National Laboratory, Denmark, are working with low band gap organics to improve solar cell efficiency, and have succeeded in creating highly absorbent materials.

The band gap is the energy difference between the top of the valence band and the bottom of the conduction band in semiconducting photovoltaic materials.

'Lower band gap materials are harder to make, but they are the way forward,' says Frederik Krebs, who leads research on organic solar cells at the centre.

Krebs' group is working with state of the art, low band gap materials such as polythiophene and poly-3-hexylthiophene (P3HT).

'Light ranges in wavelength from 350–4,000nm, but P3HT only absorbs light up to 600nm – so a lot of the sunlight is wasted,' explains Krebs.

From 350–600nm there are a limited number of photons, and that number determines the cell's maximum efficiency.

'We've made materials with 1,500nm absorbance,' says Krebs. 'But then there is a problem getting a high voltage.' Since voltage times current equals the maximum theoretical power, this needs to be solved.

To do so, Krebs and his team are matching the photon energy levels in the materials – a difficult task because of the small band gap. The researchers are using chemistry to modify the materials, and this is where

Hot topic: what is holding back organic solar cells?

'The main obstacle is the lifetime of the devices under illumination. Hopefully solar cell applications will benefit from the encapsulation techniques for OLEDs, which are approaching acceptable lifetimes.'

- Professor Keith Barnham, Imperial College London

'A big hurdle is stability. Organic cells can be encapsulated, but that increases the cost substantially. The materials that can keep water and oxygen out are expensive, and this can defeat the point of using organic solar cells. For stability, we need either to find a low cost encapsulation solution, or to develop more fundamentally stable materials – and I hope it's the latter.'

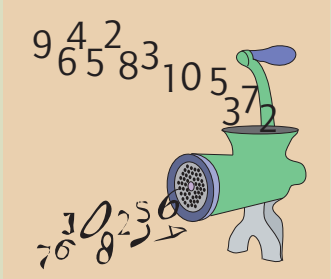
- Dr Jenny Nelson, Imperial College London

'The key to commercialising ic photovoltaics is solving the problem of exciton diffusion. The bound pair of charges need to move to the right material interface, and then to the electrodes. This can be solved by improved material morphology.'

- Professor Laurens Siebbeles, Delft University of Technology

'Right now the efficiencies are very low. In part, this is because the basic science behind organic semi-conductors is not that well understood. There needs to be a lot more research into charge generation and carrier transport. They'll need to reach reasonable efficiencies of perhaps 10%.'

- Tom Surek, PV programme manager at the National Renewable Energy Laboratory, US



Number cruncher

x500

Concentrator to be used on solar-enabled blinds

47%

Price increase in 2006 for solar cells in India

3km

Length a single Nanosolar cell can reach

350–4,000nm

Wavelength range of light

organic materials help.

'The advantage of organic materials comes in here, because you can go in and change the materials, play around with the molecules,' says Krebs.

'You can see, for example, photochemical degradation taking place, and take countermeasures to suppress it.' This chemistry would be harder to do with inorganic materials, as they are less easy to engineer.

'We're about four years or more behind OLEDs and POLEDs, which are starting to reach the market now,' says Krebs. 'Although there are different issues, we will benefit from some of the work that's being carried out on those.'

Click here for more about Riso National Laboratory

Semiconductors inspired by nature

Sea sponges and electronic materials may appear strange bedfellows, but the primitive marine creatures are proving an inspiration to chemists looking for new ways to fabricate semiconductor devices.

A team at the University of California, Santa Barbara, is using knowledge gained from studying sea sponges to make semiconductor devices that convert light into electricity, the goal being to make cheaper, more efficient solar cells.

Traditional semiconductor manufacturing is a costly, energy-intensive and inefficient business. But nature has evolved simple and elegant ways of making complex nano and microstructures using only simple inorganic materials.

The sea sponge's solution is to extract silicic acid from seawater and convert it into silica, and Daniel Morse, research leader, wants to know how the sponge manages this remarkable feat of biological engineering.

But the problem with biology is that it is messy, and electronics engineering requires ultra-pure materials.

It appears that behind the action of the sponge's biological enzymes lies just ammonia and water. By combining the precursors of metal oxides with water, and exposing the mixture to ammonia gas, it is possible to create films of highly crystalline semiconductors with a complex nanostructure, which could improve the performance of photovoltaic devices.

According to Morse: 'The advantages of controlled biological catalysis have been captured in a process dominated solely by chemical physics, without the use of organic molecules whose presence tends to degrade the electronic performance of the resulting semiconductors.'

Other applications include high-density batteries and ferroelectric random access memory (FeRAM), and high-resolution IR detectors. These technologies are currently under investigation by Morse's group in collaboration with a number of industrial partners.

For his work, Morse has been named by Scientific American magazine as one of the top 50 investigators of the year.

Click here for more about Daniel Morse

Encapsulation technology

A lot of the research carried out on OLEDs will be applicable to organic PVs – particularly encapsulant solutions to prevent degradation. Multinational DELO specialises in advanced sealants for OLEDs. 'The main issue for OLEDs is reducing permeability to water and oxygen,' says Ross Jones, UK regional sales manager. 'I believe our sealants are very transferable to the PV sector.'

Jones says that the most important factor is not permeability at room temperature, but at high heat and humidity – factors that will impact PVs designed to operate outside. 'When there are different substrate materials, the thermal expansion coefficients can also be different, which brings stress into the system and can damage it,' says Jones. 'This is solved by adding flexibility. We have developed sealants that are designed to be flexible, which could be of use for PVs.'

> "We're about four years or more behind OLEDs and POLEDs, which are starting to reach the market now"
>
> Frederik Krebs, Risø National Laboratory

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