Payback time

Energy **33,** 224–232 (2008)

Using solar panels to generate electricity is ultimately an environmentally friendly process, despite the huge amounts of energy used to produce the panels, according to an Italian researcher who has carried out a detailed life-cycle assessment of electricity generation from photovoltaic cells.

Anna Stoppato, from the University of Padova, looked at mass and energy flows over the whole production process, starting from silica extraction to the final panel assembly, and considered the most advanced and consolidated technologies for polycrystalline silicon panel production. She found that the most critical phases are the transformation of metallic silicon into pure polysilicon and the panel assembly, which uses energy-intensive materials such as aluminium and glass.

"The most important results of the analysis are the calculation of a gross energy requirement of 1,494 MJ per panel (0.65 m^2 surface area) and of a global-warming potential of 80 kg of equivalent CO_2 per panel," says Stoppato. "I also evaluated the energy pay-back time and I estimate it to be shorter than the panel operation life even in the worst geographic conditions."

Stoppato also looked at the energy return factor, which is defined as the ratio between expected panel life (28 years) and the energy pay-back time. It represents how many times a typical photovoltaic plant with 36 cells pays back the energy needed for its production. She found that a photovoltaic plant can pay back this energy more than eight times.

Dipole alternative

Appl. Phys. Lett. **92,** 053507 (2008)

Researchers at the University of Toledo, USA, have developed an alternative way of creating the electric field required in photovoltaic cells to effectively separate the photo-generated electrons and holes. Instead of a field formed by the electric contact between p- and n-types of semiconductors, Diana Shvydka and Victor Karpov suggest that the electric field can be generated by aligned electric dipoles embedded in a photoconducting host.

These electric dipoles are simply semiconductor nanoparticles, such as wurtzite CdS and CdSe or similar materials that are pyro- and piezoelectric. Some ferroelectric nanoparticles may also be suitable.

"These dipoles do not even have to be in electric contact with the host material, which makes the system extremely flexible to implement," says Karpov. "In contrast, p–n and similar junctions require a high-quality electric contact between the two materials, which sets major restrictions on the photovoltaic cell design."

The researchers claim that this concept can be used with a variety of host materials that can be polymers, liquids, amorphous or polycrystalline. "We have shown that the generated field from these dipoles can be uniform and strong enough, around 3×10^4 V cm^{-1}, to separate electron–hole pairs and run significant drift currents," says Shvydka. "Our suggested structure does not rely on p–n or Schottky junctions and can be tunable in a broad range of parameters."

Shvydka and Karpov do not project extremely high absolute efficiencies for nanodipole photovoltaics and expect them to be at the level of the best existing thin-film photovoltaics (12–15%). "However the relative cost of their generated power (in dollars per watt) can be ten times lower than that of any of the existing photovoltaics," says Karpov.

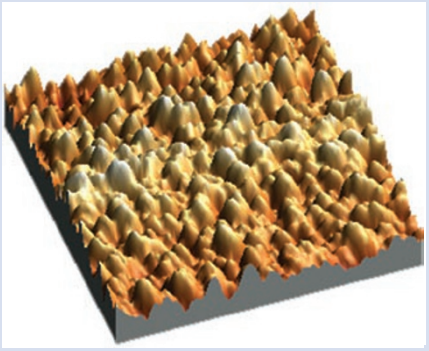
Increased efficiency

Appl. Phys. Lett. **92,** 053310 (2008)

Researchers in the USA have broadened the spectral response and increased the power-conversion efficiency in a single organic thin-film photovoltaic cell by creating simultaneously active, parallel heterojunctions with two donor materials.

The researchers used copper phthalocyanine (CuPc) and tin(II)-phthalocyanine (SnPc) as donor materials and a single C_{60} acceptor. In previous work using this combination of materials, an ultrathin intermediate donor layer was grown in discontinuous islands. However, when thicker than 5 nm, this layer formed a continuous layer that blocks interactions between the acceptor and the other donor material.

In this new work, Fan Yang and colleagues from Princeton University and the University of Michigan, demonstrate a two-donor, one-acceptor cell. Controlled crystallization of the intermediate donor layer ensures the formation of nanocrystalline islands that allow the acceptor to form simultaneously active, parallel heterojunctions with both donors. Moreover, the spectral photoresponse of these multiple heterojunction cells is significantly broadened compared with the conventional single donor–acceptor heterojunction cell. The researchers anticipate that optimization of the choice of material and crystal size will further improve the efficiency of this type of solar cell.



Nanotube hybrids

Nanotechnol. **19,** 115601 (2008)

Although research on the use of single-walled carbon nanotubes (SWNTs) as the acceptor in polymer photovoltaic cells is making great progress at present, their poor dispersion in a polymer matrix has greatly hindered the overall performance of the devices. Researchers in China think they have come up with a solution. They have developed a bulk heterojunction structure based on a poly(phenyleneethynylene)/SWNT composite. They found that it achieved better dispersion and higher performance when compared with a common control device based on a poly(3-octylthiophene)/SWNT composite layer.

Qian Liu and colleagues from the Tianjin University of Technology and Nankai University claim that theirs is a new physical approach to the improvement of the dispersion of SWNTs in a polymer matrix based on the design of the polymer molecule.

Poly(phenyleneethynylene) is a class of rigid-rod conjugated polymer composed of aromatic rings and alkyne functional groups, which can form a hybrid with SWNTs. The good dispersion of the SWNTs in the poly(phenyleneethynylene) matrix makes this composite a potential candidate in photovoltaic applications. At present, a limitation of the donor material, the poly(phenyleneethynylene), is its narrow absorption band, which hinders its photovoltaic performance, especially in terms of its current density. The researchers believe this problem can be overcome by introducing other functional groups into the backbone or side chain to improve the ability of harvesting solar energy. By broadening its absorption band, a higher current density and energy-conversion efficiency can then be expected.