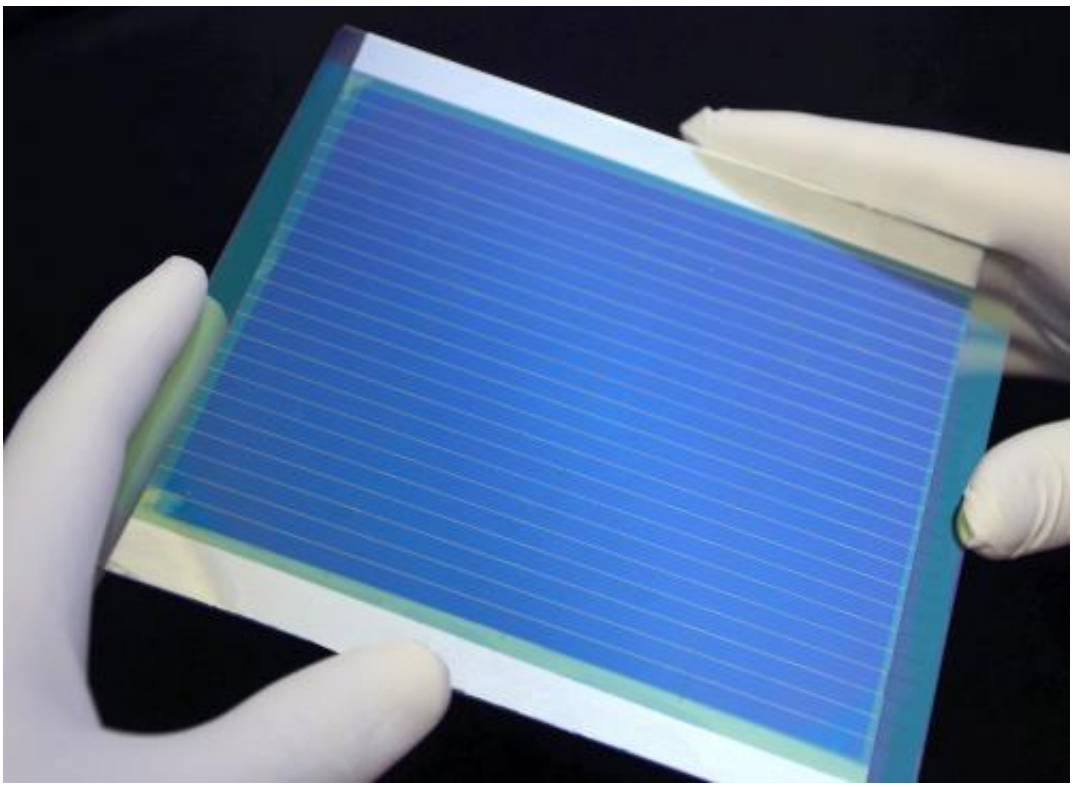
Researchers achieve record 8.4 percent conversion efficiency in fullerene-free organic solar cells

March 11 2014, by Hanne Degans



Imec's novel fullerene-free OPV cell concept was used to process an OPV module (156cm2) with a conversion efficiency of 5.3%.

In this week's *Nature Communications* Imec presents the development of fullerene-free organic photovoltaic (OPV) multilayer stacks achieving a record conversion efficiency of 8.4 percent. This breakthrough

achievement is an important step to bring organic photovoltaic cells to a higher level in the competitive thin-film photovoltaics marketplace.

Organic solar cells are an interesting thin-film photovoltaic technology due to their compatibility with flexible substrates and tunable absorption window. Although the power conversion efficiency of organic solar cells has increased rapidly in the last decade, further enhancements are needed to make the production of organic photovoltaics more easily scalable into industrial production processes. Imec's organic solar cells with record 8.4 percent power conversion efficiency were realized by introducing two innovations. Firstly, the implementation of fullerene-free acceptor materials resulted in high open-circuit voltages and useful absorption spectra in the visible. Secondly, high short-circuit currents were achieved by developing a multilayer device structure of three active semiconductor layers with complementary absorption spectra, and an efficient exciton harvesting mechanism.

Fullerenes are the dominant acceptor materials in current OPV cells due to their ability to accept stable electrons and their high electron mobility. However, the small absorption overlap with the solar spectrum limits the photocurrent generation in fullerene acceptors, and their deep energy level for electron conduction limits the open-circuit voltage. Imec implemented two fullerene-free materials as acceptor, increasing open-circuit voltages compared to OPV cells with fullerene acceptors.

To increase the efficiency of organic solar cells, complex tandem architectures are often proposed to combine the exciton harvesting of multiple photo-active materials. The imec team now proposes a simple three-layer stack to improve the spectral responsivity range. This device architecture comprises two fullerene-free acceptors and a donor, arranged as discrete heterojunctions. In addition to the traditional exciton dissociation at the central donor-acceptor interface, the excitons generated in the outer acceptor layer are first relayed by energy transfer

to the central acceptor, and subsequently dissociated at the donor interface. This results in a quantum efficiency above 75 percent between 400nm and 720nm. With an open-circuit voltage close to 1V, a remarkable power conversion efficiency of 8.4 percent is achieved. These results confirm that multilayer cascade structures are a promising alternative to conventional donor-fullerene organic solar cells.

More information: "8.4% efficient fullerene-free organic solar cells exploiting long-range exciton energy transfer." Kjell Cnops, et al. *Nature Communications* 5, Article number: 3406 DOI: 10.1038/ncomms4406 . Received 02 September 2013 Accepted 07 February 2014 Published 07 March 2014

Provided by IMEC